SIEMENS
REVIEW

VOL. XXVIII · 1961 · NO. 4 · PAGES 103-136

PRINTED IN GERMANY

Ordering

The "Siemens Review" appears ten times a year. Orders should be addressed as follows: Siemens-Schuckertwerke AG, Hauptwerbeabteilung, "Siemens Review", Erlangen, Werner-von-Siemens-Straße 50

Inquiries

All inquiries with regard to contents and despatch of the "Siemens Review" should be addressed to the editors: Schriftleitung "Siemens Review", Siemens-Schuckertwerke AG, Hauptwerbeabteilung Erlangen, Werner-von-Siemens-Straße 50

Reprint

The editors will be pleased to grant permission for material appearing in this Review to be reprinted elsewhere, provided that the source is given. Such permission should, however, be applied for in each case. Photostats of individual articles may be made – also for professional purposes.

Contributors to this Issue

Braun, K.
Siemens & Halske Aktiengesellschaft
Wernerwerk für Fernsprechtechnik

Fordan, G.
Siemens & Halske Aktiengesellschaft
Wernerwerk für Fernsprechtechnik

Fried, Th.
Fernmeldeamt Mannheim

Haag, A.
Siemens & Halske Aktiengesellschaft
Wernerwerk für Weitverkehrs- und Kabeltechnik

Henke, H.-J.
Siemens-Schuckertwerke Aktiengesellschaft
Technische Stammabteilung

Kirchner, W.
Siemens-Schuckertwerke Aktiengesellschaft
Technische Stammabteilung

Leonhard, W.
Siemens-Schuckertwerke Aktiengesellschaft
Technische Stammabteilung

Neuffer, I.
Siemens-Schuckertwerke Aktiengesellschaft
Technische Stammabteilung

Preis, W.
Siemens-Schuckertwerke Aktiengesellschaft
Technische Stammabteilung

Reese, A.
Siemens-Schuckertwerke Aktiengesellschaft
Technische Stammabteilung

Schmidt, F.
Siemens-Schuckertwerke Aktiengesellschaft
Nürnberger Zählerwerk

Steger, E.
Siemens & Halske Aktiengesellschaft
Wernerwerk für Fernsprechtechnik

Voss, H.H.
Siemens & Halske Aktiengesellschaft
Zentral-Laboratorium

SIEMENS REVIEW · VOL. XXVIII · APRIL 1961 · NO. 4 · PAGES 103 — 136

CONTENTS

Inside a large carrier station used for long-line telephony

Carrier transmission facilities for 7000 voice circuits are monitored by the attendant at her desk

SIEMENS

REVIEW

SIEMENS & HALSKE AKTIENGESELLSCHAFT · SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT

BERLIN · MÜNCHEN · ERLANGEN

VOL. XXVIII · 1961 · NO. 4

Punched-card Control for Mixing Plants

By Walther Kirchner

The automatic control of mixing plants in foodstuff factories, animal-food mills and malthouses has the same objective as any other kind of automation, namely higher production, i.e. increase of output to the limit of the capacity of the machines while maintaining high quality, and relieving personnel from routine work. The complete programme of a mixing process can now be automatically controlled by means of punched cards.

The common principle of such mixing plants is that the various constituent materials ("ingredients") are stored in a number of storage bins and, after being weighed by suitable means, are worked up to a final product in mixers and a variety of machines.

Punched-card control offers the following advantages:

1. As the materials for the particular formula and their proportionate weights are automatically selected, incorrect mixes cannot be caused by wrong setting of the desired weight or mistaking the storage bin. Errors due to inaccurate reading of pointers on the dials of the weighing machines or incorrect counting of the tipping of scales set to a fixed weight are also eliminated.

2. The automatic equipment is so designed that in case of a disturbance, as for example failure of the power supply, breakage of a mechanical part or emptying of a storage bin, the process will be interrupted but incorrect mixes cannot be produced.

3. In certain mixing processes, which are described later, during the weighing of a mix the materials to be weighed have to be changed, in some cases as many as four times. It would be impracticable to do this manually as several scales are involved, which would have to be changed over practically simultaneously; an economic speed can only be attained by automation, i.e. with the aid of punched-card control.

4. If there are a specially large number of storage bins (thirty or more is not unusual), changeover to a new mix by manual means would take considerable time; this would entail an undesirable long wait for the customer or lower output if the product were being made for stock. When, however, a punched card is prepared in the office the change of formula can be made with negligible loss of time.

5. The coding of a mixture formula by means of punched cards prevents the composition becoming generally known; the punched card thus helps to keep the formula of a mixture secret.

6. When different materials are weighed by the same scale, account must be taken of the fact that they do not flow into the weigh hopper equally quickly. The instant for stopping the feed or changing over from bulk stream to dribble stream depends on the material. This can be effected when a punched card is used. This applies also to the residual material left in the feeder to the scale after the discharger of the storage bin has been closed. With manual operation it would be almost impossible to take account of this trapped material with sufficient accuracy.

7. For the subsequent treatment of the materials for mixing, a variety of machines and transport paths are required; automatic control of the individual machines also by means of punched cards is possible, including cases where each ingredient of a mix has to be treated differently.

8. For the sake of completeness it may be mentioned that with automatic control the formula can be repeated indefinitely or a preset number of times.

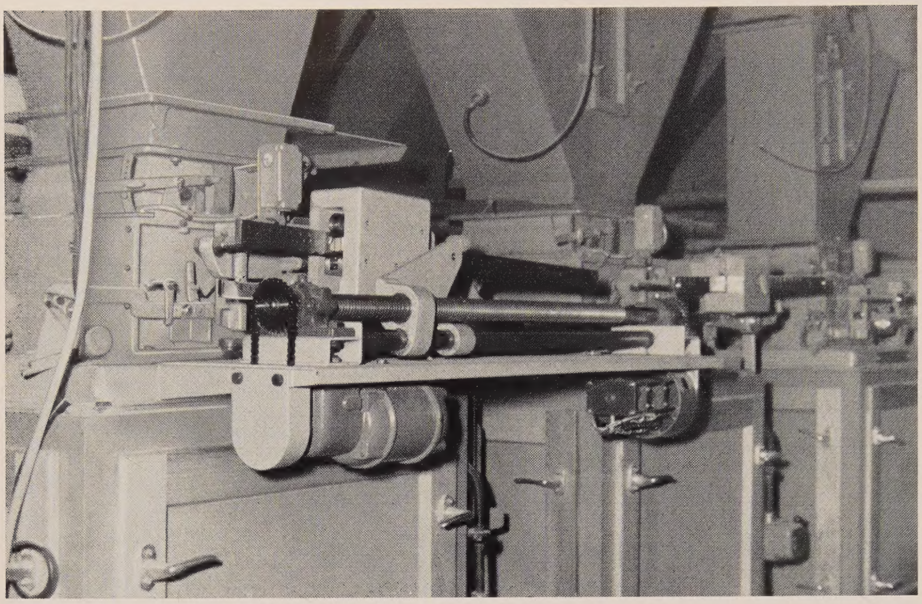


Fig. 1 Electrically controlled sliding-weight scale (cover removed) in an animal-food mill

How the punched-card equipment for automatic control of a mixing process should be made up and what apparatus is the most suitable depends primarily on the production process. Its special features must be known before an automatic control equipment can be designed. Opinions still differ as to the relative merits of the various methods. It is, however, of great importance that the scales should be built for the particular application and account must be taken of the differences in their construction in the design of the control equipment.

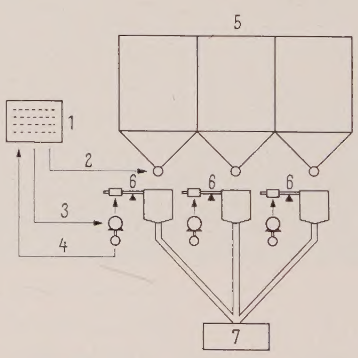
It may be mentioned that the punched-card control systems originally developed for animal-food mixing and for malthouses are equally suitable for similar mixing processes in other branches of industry. They have been successfully applied, for example, to mixing plant used in the manufacture of plastic materials and rubber.

Weigh-charging method

With this method each storage bin containing an ingredient of the formula has its own scale, the hoppers of which are emptied simultaneously into the mixer.

Sliding-weight scales (Fig. 1) lend themselves particularly well to simple and reliable application of automatic control. Such weighing machines are built for a holding capacity of about 50 kg (110 lb), the minimum weighable quantity being about 1% of full scale value, i.e. 0.5 kg (about 1 lb). Fig. 2 is a schematic diagram of the weigh-charging method with three storage bins each with a sliding-weight scale. The punched card determines which of the three materials shall be included in the particular mix; the punched card also sets the desired weight for each scale. When the weights are automatically set, for example, by means of positioning motors, the dischargers of the storage bins open automatically and the material flows into the scales until the required quantity is nearly reached. The bulk-stream is then stopped and a changeover made to dribble stream. When finally exact taring is attained the dribble stream is also stopped. When weighing has been completed by all scales and the mixer is free to receive a batch, all the scales are emptied simultaneously; when required, the operating cycle is automatically repeated. The number of cycles can either be controlled by the punched card or it may be set separately so that the same punched card may be used for any number of repetitions.

The number of scales required for the above method can be reduced if the same scale is used for several constituent materials. The scales are then of the multi-feeder type and enable up to four ingredients of a formula to be weighed consecutively by one machine. If two or more materials are required in the same formula, when a batch is being weighed the punched-card control equipment must be switched over from one storage bin



1 Punched card
2 Selection of ingredients
3 Setting of weights
4 Supervision of weight setting by variable-position limit switch
5 Silo with three storage bins
6 Sliding-weight scale
7 Mixer

The weigh hoppers discharge simultaneously into the batch mixer

Fig. 2 Schematic diagram of a mixing plant with single-feeder sliding-weight scales controlled by punched cards (weigh-charging method)

to another; in addition, the punched card must reset the scale to the desired weight for the next material. As the first material weight will still be in the weigh hopper the desired weight setting must be the sum of the weights of the first and second materials. With four-feeder scales the storage-bin selection and desired weight must be changed three times during a charging cycle. Adjustment of a sliding weight would take too long and balance weights are therefore deposited magnetically. Like the sliding-weight scales, these magnetically adjusted scales are also supplied for a holding capacity of about 50 kg (110 lb).

With multi-feeder scales the punched card for each scale must be read as many times as there are feeders. This is carried out separately for each scale (Fig. 3) and every time a weighment has been completed. It is, however, undesirable to "read" say all the first feeders simultaneously and then all the second feeders and so on, because this would unnecessarily prolong the total filling time. All the weighing machines are again emptied simultaneously.

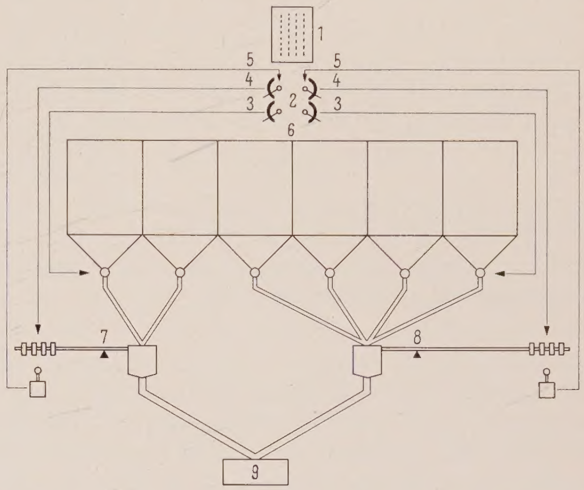
Weigh-batching method

A mix formula may also be weighed with only one scale for the whole plant instead of several. This is called weigh-batching.

With this method, as with multi-feeder scales, the ingredients are fed consecutively into the large weigh-hopper where they accumulate. Such scales may hold from 1 to 2 tons. Whereas the sliding-weight and magnetically-adjusted scales work to an accuracy of about 1% which is adequate for the mix, the indicating-type scales used for weigh-batching must work considerably more accurately to obtain a sufficiently accurate mix. If with weigh-batching, for example, in an indicating-type scale with a holding capacity of 1 ton ten quantities each of 100 kg (220 lb) are weighed, each of these must be accurate to within 0.1% if the error in the mix is not to exceed 1%. The equipment must be designed to set the desired weight by means of the punched card and when determining the actual value to take account of each individual weighment. This is described in detail in another article[1].

Weigh-batching entails constructional difficulties in that the bins must be placed close to the scale, as otherwise it is difficult to take account of the material remaining in the feeders.

In weigh-batching the ingredients are fed sequentially under punched-card control, a desired weight being set for each on the scales. When the desired quantity is reached the feed is automatically stopped. Account must, however, be taken of the differing rates of flow of the materials to be weighed. This is done by setting a smaller weight than the actual desired weight, the bulk stream of material being reduced to a dribble when this setting is reached. Excessive errors may, however, still occur owing to the dynamic action of the remaining dribble stream since at the moment of cut-off some material is still falling freely in air; the actual filling height in the weigh-hopper is thus of great importance. To obtain the required accuracy of 0.1% or less the dribble stream also must therefore be cut off shortly before the desired weight is reached. This allowance depends on the material concerned and should preferably not be preset by the punched card but by suitable switching elements

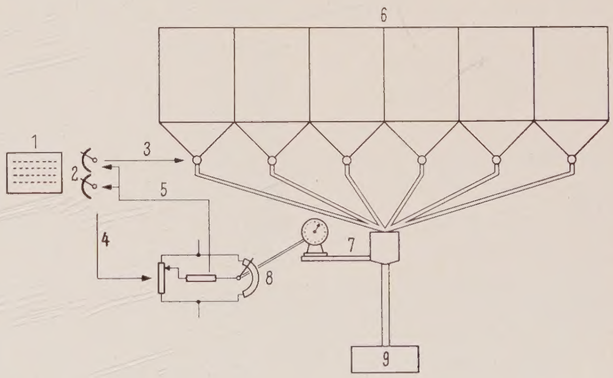


1 Punched card
2 Selectors*
3 Selection of ingredients
4 Setting of weights
5 Supervision of weight setting by limit switches
6 Silo with six storage bins
7 Two-feeder scale
8 Four-feeder scale
9 Mixer

The weigh hoppers discharge simultaneously into the batch mixer

* German Patent (DBP 896148)

Fig. 3 Schematic diagram of a mixing plant with multi-feeder scales with magnetically deposited balance weights controlled by punched cards



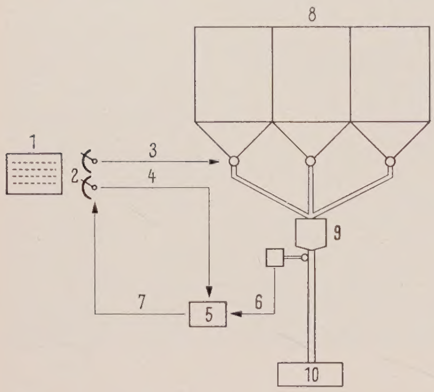
1 Punched card
2 Selectors
3 Selection of ingredients
4 Setting of weights
5 Switching of the selectors by measuring element
6 Silo with six storage bins
7 Indicating-type scale
8 Potentiometer on the pointer spindle
9 Mixer

The weigh hopper discharges after cumulative weighing of all the ingredients of the formula

Fig. 4 Schematic diagram of a mixing plant with indicating-type scale controlled by punched cards (weigh-batching method)

1 Reese, A.: Punched-card Equipment for the Control of Mixing Plants. Siemens Review XXVIII (1961) pp. 106 to 110

associated with the selection of the individual storage bin. When the desired weight is set for the ingredients which follow account must be taken of the material already weighed and still in the weigh-hopper. This is not emptied until the complete batch of materials required for the formula has accumulated (Fig. 4).



1 Punched card
2 Selector
3 Selection of ingredients
4 Desired number of weighments
5 Counter
6 Counting of weighments by limit switch
7 When the prescribed number of weighments of an ingredient has been completed: switch to the next ingredient
8 Silo with three storage bins
9 Fixed-weight scale
10 Mixer

The weigh-hopper discharges into the mixer after each filling

Fig. 5 Schematic diagram of a mixing plant with fixed-weight scale controlled by punched cards

As a variant of the weigh-batching method, only a single scale is provided as before for the whole plant but the individual materials are not accumulated in the weigh-hopper. Variable settings of the desired weight are then dispensed with, the scales being set for a fixed weight, for example 20 kg (44 lb). The quantities required for a particular formula are obtained by filling and tipping a scale several times. The total weight of each ingredient must then, of course, be a multiple of the desired weight for which the scale is set. In addition to the selection of the ingredients for a particular formula, in this process the punched-card equipment has the function of prescribing the number of tips of the scale for each ingredient (Fig. 5). The feed of material from a storage bin is stopped when the prescribed number of tips has been completed. It is now automatically determined whether the next ingredient is required in the formula and, if so, the necessary number of tips is prescribed for the new material by the punched card. As with weigh-batching the punched card must be read sequentially for each storage bin to determine whether material is required from it and, if so, how much. Although this weighing and mixing procedure can be carried out with scales of comparatively simple design it takes more time than the methods previously described. It may, therefore, be used with advantage when the subsequent processing of the mix requires considerably more time than the weighing.

Punched-card control equipment is very easy to handle. The supervisory methods familiar in automatic control technique enable punched-card control to operate automatically. Alarm devices are, of course, provided for all disturbances which may occur in practice. Although these interrupt the automatically-controlled process any risk of a consequent wrong mix is prevented.

In spite of the many functions which a punched-card control system has to fulfil the design may be comparatively simple and the layout easy to supervise. The front plate of a switch panel provided for the purpose includes, in addition to the actual punched-card reader, only a few operating and indicating devices.

Punched-card Equipment for the Control of Mixing Plants

By Adolf Reese

Punched-card control equipments developed by Siemens-Schuckertwerke and their advantages for mixing plants in foodstuff factories, animal-food mills and malthouses have been discussed in the previous article[1].

Apparatus and equipment will now be described, which have been developed to fulfil the many tasks to which punched-card control may be applied.

An essential condition was that the apparatus should meet the requirements of foodstuff factories, animal-food mills and malthouses, i. e. of plants where repetitive weighing operations are involved. It was known from the start that a separate, dust-free and preferably air-conditioned room would not always be available for the installation of the control and operating equipment. A particular point was therefore made of robust design so that the apparatus should work satisfactorily even in dust-laden atmospheres.

The relays employed were combined in separate dust-tight units, the purpose of which is described later.

Another condition was that the control gear should be so simple that it could be operated without difficulty by unskilled personnel.

It was desired that the punched-card reader should be an instruction transmitter suitable for all weighing

1 Kirchner, W.: Punched-card Control for Mixing Plants. Siemens Review XXVIII (1961) pp. 103 to 106

systems and whereby it should be possible by simple means to carry out the desired programming.

Similar switching functions are carried out, for example, with cross-bar distributors in which the desired programme is set up by individual plugs or adaptor plates. Other well known methods in successful use are the reading of prepunched cards in the Hollerith system and the reading of a punched continuous strip.

These devices are designed for special programmes. An apparatus for general use in industrial mixing plants must, however, be suitable for both weigh-batching and weigh-charging of the ingredients.

Whereas with weigh-batching only one ingredient of a mix is "read" at a time, with weigh-charging the instructions on the punched card must be available simultaneously for all the ingredients.

The punched-card reader incorporates the following safety measures:

- The control is inoperative unless the lid of the apparatus is closed.
- The control equipment cannot operate unless a punched card is inserted.
- If in the case of extensive mixing programmes requiring a number of punched-card readers, punched cards not relating to the same formula are inserted in error, the control is blocked.

The determination of the weights and number of tips and the selection of the individual ingredients by relays which electrically represent a tetrad (4-bit) notation to be described later has made possible the development of an instruction transmitting device in the form of a punched-card reader which not only fulfils all the above mentioned requirements but has very few contacts.

The punched-card reader is accommodated in a robust cast-iron case with quick-release lid. Fig. 1 illustrates the construction of such an equipment. In the lid and insulated from it are conducting metal bars, opposite to which in the lower part of the case are spring-mounted contacts. The arrangement is electrically equivalent to a series of make contacts, which can be multiplied by means of relays. When a punched card is inserted a contact is made wherever there is a hole, but contact is prevented wherever there is no hole.

It has been found that almost all programming can be accomplished with a punched-card reader with 20×20 = 400 contacts with six additional contacts for interlocking purposes. If one punched-card reader is inadequate for the number of ingredients in a particular plant, two or more are used.

To ensure a long service life the punched card is made of moulded sheet about 3 mm (0.12 in.) thick and can be programmed for any purpose in a simple manner by means of a drilling template and a punched-card code.

Notches on the sides of the card (visible in Fig. 2) prevent it from being inserted the wrong way round.

A number of cards are supplied with each punched-card equipment, in which it is only necessary to drill the holes required for programming.

The punched card may be so divided up that, for example, each line represents part of a formula, the various weights being marked on the relevant line.

The contacts of the punched-card reader are multiplied by means of relays. These relays carry out the functions necessary for control, for example, pick-up or drop-off of the weight magnets, selection of the appropriate ingredients and repeated tipping of a weigher.

With a reader working on the decimal system to represent the numbers 1 to 100 (0.5 to 50 kg) for one part of a formula alone at least 18 contacts and therefore 18 holes in the punched card would be necessary, namely the numbers 1 to 9 and 10 to 90. The tetradic coding system, on the other hand, makes possible a comparatively small type of punched card and reader as the numbers 1 to 100 can be represented with only eight contacts and therefore eight holes. If, for example, the coding 1 2 4 5 10 20 40 50 is used, the number 78 is made up from 50 + 20 + 5 + 2 + 1.

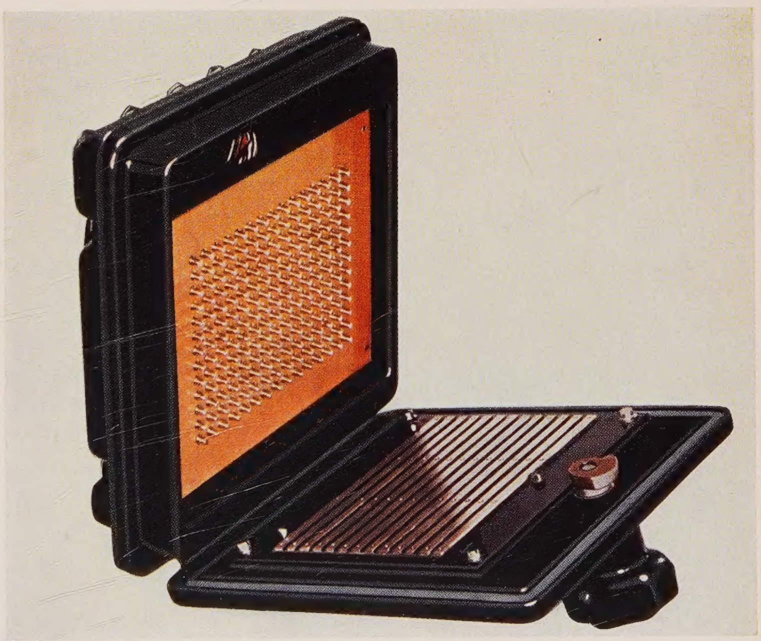


Fig. 1 Punched-card reader, open

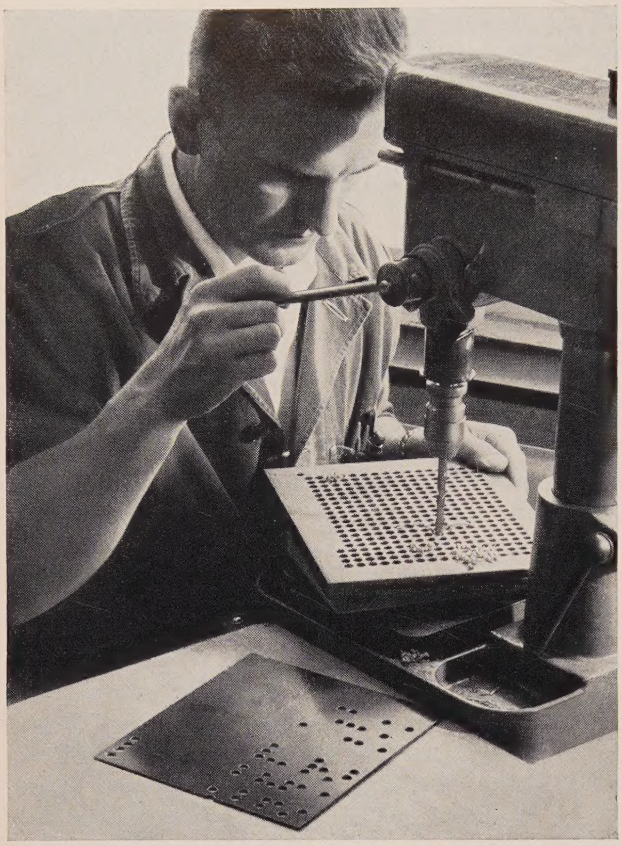


Fig. 2 Drilling the holes in a punched card by means of a template. In the foreground is a finished card

The same applies to the assembly of tip-counting relays, when multiple-tipping weighers are used. If, for example, multiple tipping up to a maximum of 395 times is required, contacts on the punched-card reader and, therefore, relays are required for 1 2 4 5 10 20 40 50 100 and

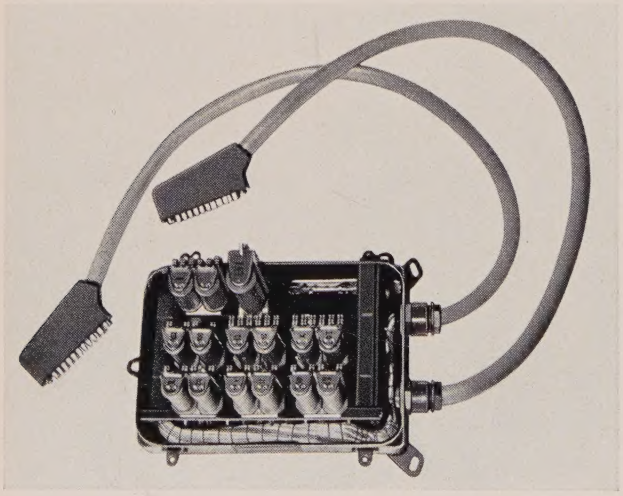


Fig. 3 Group of weight-setting or tip-counting relays (cover removed). Multiple plugs allow easy replacement of the unit

200. As a contact-multiplying relay, which may be considered as weight-setting or tip-counting relay, depending on its function, is associated with each reader contact, the tetradic system makes it possible to limit the number of contacts and relays required to a minimum. The relays are accommodated according to application in separate, dust-tight, sheet-steel enclosed relay groups with multiple plugs (Fig. 3) so that when necessary a complete faulty relay group can easily be replaced. The fault can then be rectified in the workshop without any interruption to the process. Instead of the relay groups with multiple plugs, the relays may be mounted on plug-in chassis; they are then protected against dust as when in a drawer. Fig. 4 shows a relay chassis on which the weight-setting relays for a weighing machine are mounted.

A batch to be weighed comprises a number of bulk ingredients. Thus an animal-food mill gives the composition of a meal with albumenoid supplement for laying hens as:

Wheat	40 %
Cut barley	26 %
Crushed maize	20 %
Milo	5 %
Cut oats	5 %
Prawns or shrimps	2 %
Crushed mussel shells	2 %

With the continuous process seven scales are required for the seven ingredients, of which the prescribed quantities are weighed simultaneously and discharged together into the mixer. Instead of these seven scales, the weigh-charging process requires only two scales, each with four feeders, and with weigh-batching only one scale is employed. When one ingredient has been weighed in the weigh-charging or weigh-batching process a changeover has to be made to the next ingredient required. In the weigh-charging process, selector relays are used for this purpose and in the weigh-batching process telephone-type uniselectors because of the generally larger number of ingredients per batch.

The advantage of using selectors or selector relays is that should the mains supply fail they remain at the last selected ingredient. When the supply is restored the desired batching cycle can be correctly completed.

In all weighing processes the prescribed weights are monitored by suitable circuits; methods employed include the following:

a) With sliding-weight scales a decade limit switch is employed. This consists of three fixed, ten-segment, contact-makers with rotating brushes actuated through a maltese cross from the adjusting spindle of the sliding weight. As soon as the weight prescribed by the punched card is in agreement with the set value of the sliding weight, the positioning motor is switched off.

b) In the case of scales with magnetically deposited weights it is checked by means of limit switches whether the desired weights have been correctly deposited on or lifted off the beam.

c) With weigh-batching, the weight-setting signal usually involves no mechanical moving parts, the operation of which would have to be supervised. The actual value is derived from a highly sensitive potentiometer mounted on the pointer spindle.

The potentiometer employed should not require a torque exceeding 1 g-cm so that the accuracy of weighing may not be affected. Only then can the required accuracy of the weighing system of 0.1% be attained.

On the other hand, the linearity of the potentiometer must conform to the required accuracy of 0.1%.

By means of the punched card, resistances for a comparison bridge are introduced according to a certain code and the actual value of the pointer potentiometer is compared with this resistance combination. When the two resistances are in agreement a transistor trigger circuit in the galvanometer branch of the bridge operates, thus indicating that the scale has tared. The desired-value resistors and the actual-value potentiometer are connected into the bridge in such a way that current is always flowing in the measuring resistors. They are therefore always at the same temperature so that measurement errors due to temperature change cannot occur.

It should be noted that by the use of special circuits an accuracy of measurement higher than 0.1% can be obtained.

Fig. 5 illustrates such a transistor control unit for the weight setting by means of punched cards.

So that large amounts of material may be weighed in a short time (about 12 sec) the principle of bulk stream and dribble stream is used with almost all scales. As soon as the scale beam has almost reached the desired value, a leader contact operates and cuts down the bulk stream to a dribble stream. When the desired weight has been reached a second contact is actuated, which shuts off the dribble stream, too. Mechanically operated limit switches, light barriers or electrical overshoot switches can be used as signal transmitters for the bulk-stream and dribble-stream contacts.

Depending on the design of the scales, the feeders are first throttled by the leader contact and then completely shut off. With all kinds of weighing machines the feeder elements may be shaker conveyors, screw conveyors or down-pipes. When the bulk-stream contact operates the feeder is throttled. When the material is fed to the scales through a down-pipe a flap valve is used to limit the flow.

With indicating-type scales the bulk stream is also cut down by means of an advance signal. Provision is made so that the advance signal can be given up to 15 units before the desired weight is attained. The dribble stream is shut off by a second signal when the desired weight is fully reached.

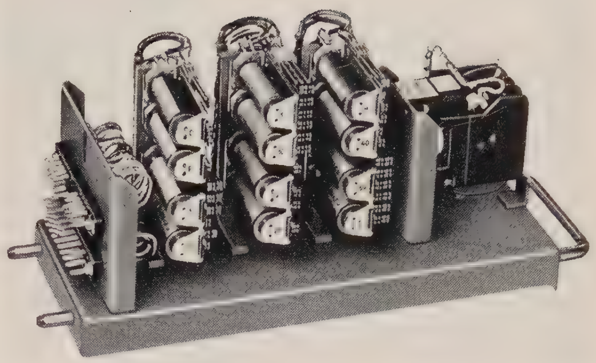


Fig. 4 Relay chassis for weight setting of a weighing machine (cover removed)

In this way, allowance can be made for the dynamic effect of the falling material which affects the accuracy of weighing especially with weigh-batching.

In the repetitive weighing process the weight is checked by counting the number of discharges of the weighing machine. For this purpose, a decade counter is used with one, two or three decades according to the maximum number of tips. A ten-position magnetic counting mechanism is used for each decade. The counter magnets, zero-position relays and relays for the decade transfer with the necessary wiring are also assembled in sheet-steel cases with multiple plugs, as used for the weight-setting relays.

The punched-card reader and the relay groups for the various functions are also enclosed in dust-tight sheet-

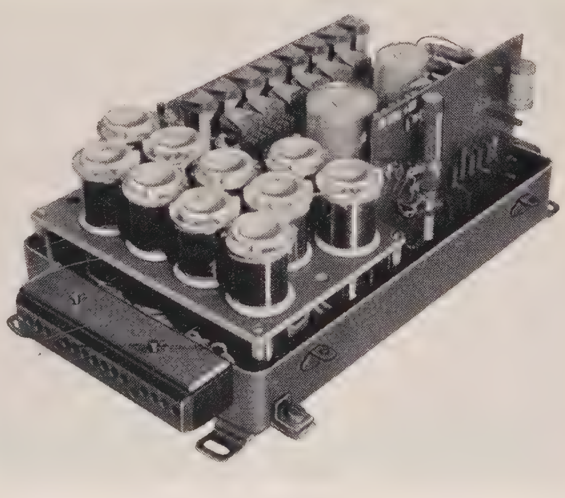


Fig. 5 Transistor control unit for weight-setting by punched card for indicating-type scales (cover removed)

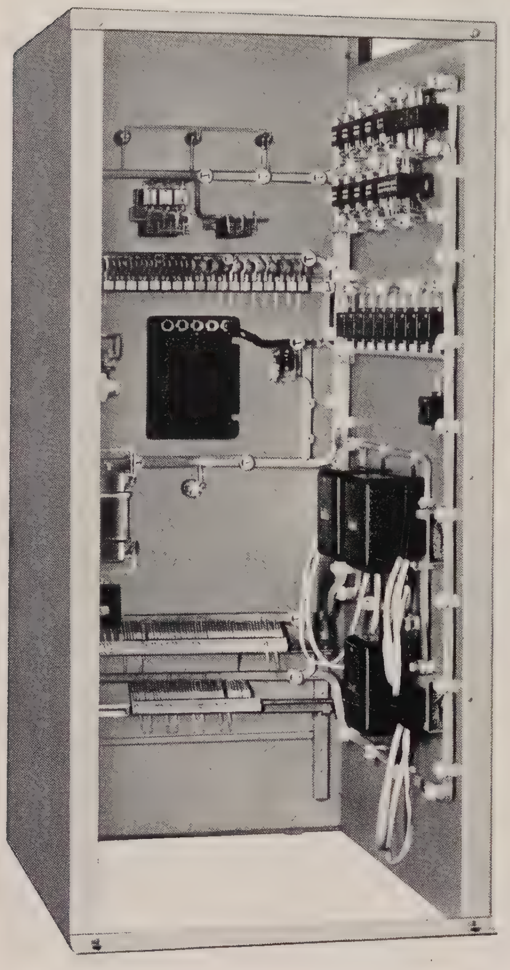


Fig. 6 Scale control cubicle (rear view)

steel cases. It has, however, been found advantageous to install all switches, etc., associated with the control in a dust-tight control cubicle, on the front of which are the operating pushbuttons and the punched-card reader. According to purpose, the control panel can be supplied for individual control or in conjunction with a luminous flow board for the rest of the control of animal-food mills, malthouses or similar mixing plant.

Fig. 6 is a rear view of a scale control cubicle with back removed. In the middle of the front plate can be seen the back of the punched-card reader; to the top right are the contactors and motor-protection circuit breakers for the feeder motors. To the bottom right are three relay groups with multiple plugs, which include the relays for setting the weights and for selecting the ingredients as well as the relays for repetitive discharge of the weighing machines.

When for operational reasons the control cubicle has to be placed at a considerable distance from the scales, the weigher control equipments proper comprising the contactors for bulk-stream and dribble-stream, weight-setting motor, magnets and rectifiers for the vibrating feeder chutes, may with advantage be placed adjacent to each weighing machine in special control boxes instead of in the common control cubicle.

The apparatus and equipments described enable punched-card control to be applied to all methods of weighing and therefore to all kinds of weighing machines commercially available. The relay groups assembled to form constructional units can be adapted to the special technological requirements of the particular mixing plant. The equipments thus make an important contribution to rationalization within industries.

Power Supply System of Mannheim's Communications Building

By Theodor Fried and Karl Braun

The Mannheim dial office area lies within an industrial center. On account of its favorable location on the rivers Rhine and Neckar, Mannheim is also an important point for the transshipment of goods. The steady growth of industry in this area and the concomitant increase in the number of telephone installations have resulted in a considerable rise in telephone traffic in recent years. Mannheim's sectional office itself currently handles some two million outgoing long-distance telephone calls a month, 90% of which are dialed by subscribers.

The important status of the Mannheim industrial area has made it necessary to install a large quantity of additional switching equipment and line plant in the sectional office area and in the sectional office itself. This additional equipment – operating on 60 v neg., 60 v pos., 212 v and 220 v a-c – also resulted in an increased power demand which is satisfied by a new power supply system installed at Mannheim's sectional office.

The heart of the fully automatic power supply system is the rectifier room. The switching panels for feeding the telephone, telegraph and long-line communications equipment are arranged in the shape of a horseshoe (Fig. 1). As the battery room is located below the rectifier room, it was possible to run the leads to the batteries by the shortest route.

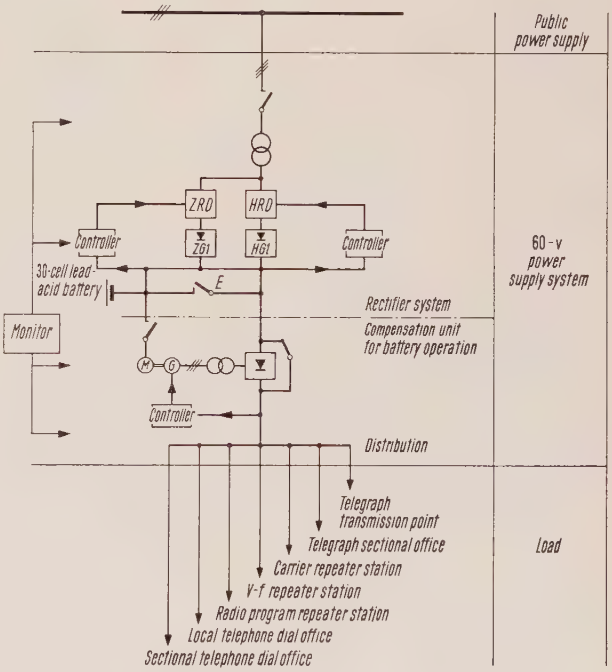
Fig. 1 Inside the rectifier room of the power supply system at Mannheim's communications office

The features of the 60-v neg. system for feeding the telephone equipment of the sectional office will be described below. The 60-v pos. system is of similar design.

As a connecting link between the commercial power supply and the loads, a power supply system has three functions. First, in the case of mains operation, it feeds the connected loads with the respective voltages required, while at the same time maintaining at full capacity the batteries that are held ready for use if the commercial power supply should break down; it also recharges the batteries in a minimum of time after they have been used.

The voltages appearing at the batteries disallow parallel connection with the loads. The circuits for feeding the loads and for charging the batteries are therefore kept separate. The main rectifiers feed the loads, whereas the batteries are fed a voltage composed of the main rectifier voltage and a variable voltage supplied by the supplementary rectifier (Fig. 2).

The main rectifiers and the supplementary rectifier are magnetically regulated. The main rectifiers supply a constant d-c of 62 v ± 2% which is specially filtered so that the frequency-weighted noise voltage will not exceed 2 mv. The supplementary voltage amounts to 4 v ± 2% for compensative charging (curve 1 in Fig. 3). If the compensative current exceeds a certain value, the charging voltage plus a supplementary voltage of up to 10 v takes the place of the compensative charging voltage (curve 2 in Fig. 3). The charging current is a function of the degree to which the batteries are charged. When the current drops to a very low value as the degree of charging of the batteries increases, the supplementary rectifier switches back to compensative charging (curve 3 in Fig. 3).



ZRD Supplementary control choke
HRD Main control choke
ZGl Supplementary rectifier
HGl Main rectifiers
G Generator
M Motor
E Discharge contactor

Fig. 2 Operating schematic of 60-v power supply system

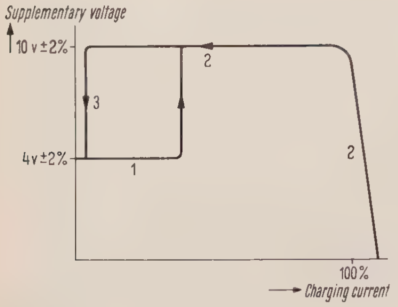


Fig. 3 Voltage curve of supplementary rectifier as a function of the load

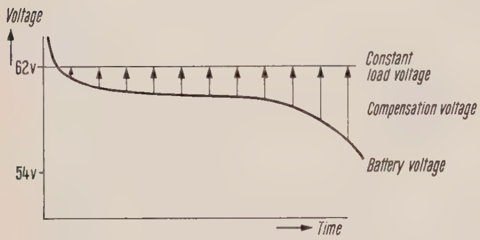


Fig. 4 Interaction of compensation voltage and battery voltage in the case of battery operation

The tolerances of the d-c voltage are adhered to in the presence of mains voltage fluctuations between –10% and +5% of the rated value and are independent of the load. This may amount to between 1.5% and 100% of the rated current. The mains frequency of 50 cps may permissibly vary by ±2%.

When the system operates on mains power, the batteries do not participate either in filtering the main rectifier voltage or in feeding the loads. The discharge contactor *E* does not connect them to the loads unless the mains power supply breaks down (see Fig. 2). For the duration of battery operation the loads are fed by respective groups of 26 cells of the batteries (see Fig. 5). These cells are connected to the lead to the loads by way of a blocking valve *Vl* through which current flows only for as long as the discharge contactor remains transferred.

The voltage of the batteries when under load depends on the value of the discharge current and on the length of the discharging period. If it is desired that the loads should also be supplied a constant voltage during power outages, recourse may be taken to a compensation unit consisting of a d-c threephase converter that likewise operates on the batteries. The generated threephase voltage is transformed, rectified, filtered and coupled into the lead to the loads. The generator is so regulated that the sum of the battery voltage and the compensation voltage always amounts to 62 v (Fig. 4). As the compensation voltage may be between 0 and 8 v, practically the full capacity of the batteries can be used up to their final voltage of 54 v. The compensation unit in the Mannheim sectional office can be loaded with 1,000 amps. If the power demand increases further, a second compensation unit will be used.

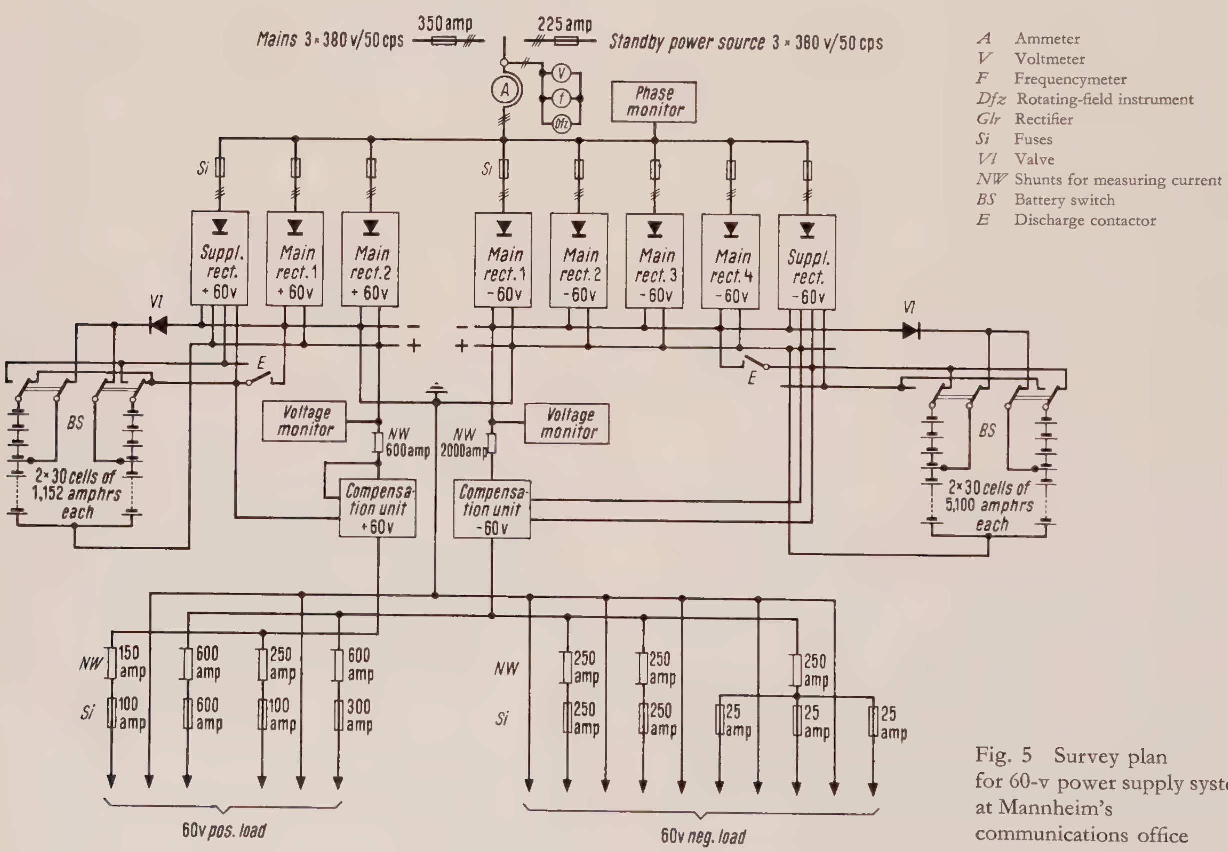


Fig. 5 Survey plan for 60-v power supply system at Mannheim's communications office

The rectifier units are designed with certain current ratings. If the power demand exceeds the current rating of the individual rectifier units, several units are connected in parallel. The 60-v power supply system of the Mannheim office operates with four main 200-amp rectifiers (Fig. 5) which cut in and out automatically depending on the changing power requirements. The system can be expanded to operate with up to ten main rectifiers.

The supplementary rectifier supplies 10 v and 600 amps, which is adequate for charging the two 5,100-amphr batteries over about 24 hours. The less the batteries have been used, the faster they will be charged.

A battery panel for 2,000 amps incorporated in the central equipment of the 60-v system and a mains supply panel complete the power supply facilities of the Mannheim office. If the power mains remains interrupted for longer than six hours a trolley-mounted standby power source can also be connected up.

Maintenance of the fully automatic power supply system is confined in general to the periodic checking of its operation. Any faults that develop are indicated on a lamp panel embodied in the monitor panel. At the power monitor desk in the rectifier room (Fig. 1) the voltages on all outgoing supply leads can be read on respective instruments and are at the same time automatically plotted by a multiple-pen recorder.

The equipment inside the rectifier room is protected from overtemperature. If the room temperature or the temperature of any item of equipment rises above a respective set value, the air-conditioning system starts up automatically. If the temperature continues to rise still further, the ventilation is increased and the momentary state indicated by both visual and audible means.

In performance and design the power supply system of the Mannheim office meets all the requirements of modern communications equipment.

With respect to the load capacity of such systems, it is possible to satisfy all the special requirements existing in dial offices and PABX's by choosing rectifiers of a suitable rating.

Transductor-fed Variable-speed Drives for Rotary Printing Presses

By Werner Leonhard and Walter Preis

When opening a newspaper or illustrated paper straight from the press, one does not generally think of the technical problems to be solved before a precision-printed large-circulation paper can be released for distribution. One of these problems concerns the drive of the rotary printing machines which are to-day used for printing all newspapers and illustrated papers, not to mention the many periodicals, prospectuses and brochures.

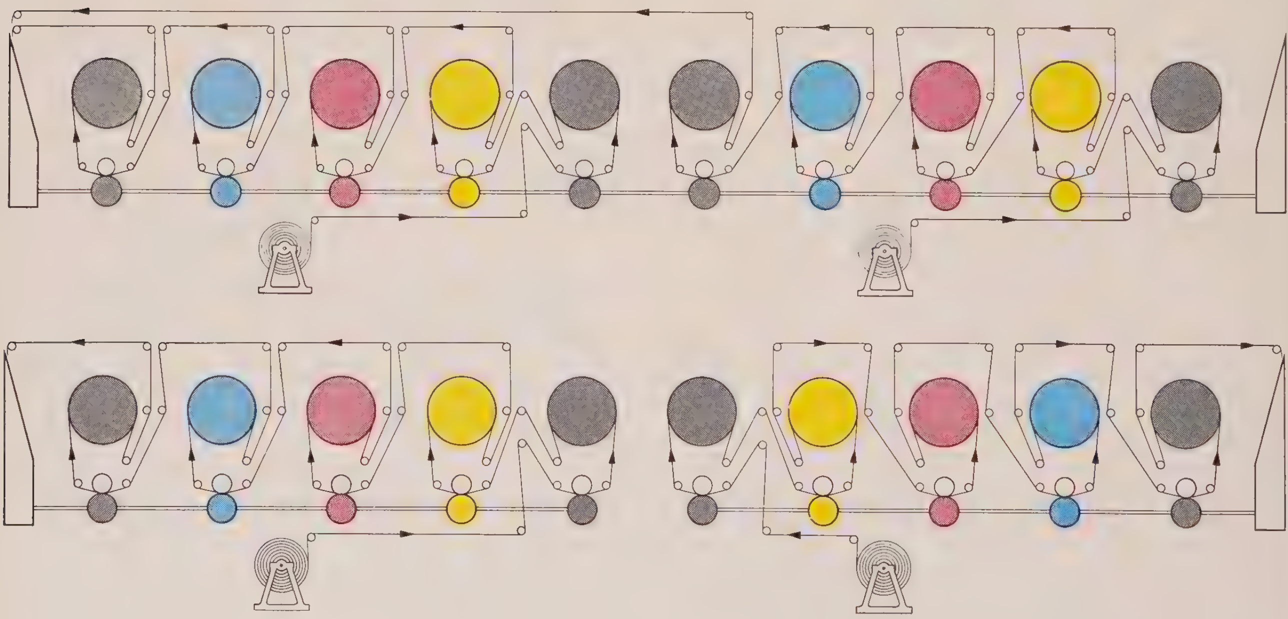
Fig. 1 shows by way of example a web-fed rotogravure press. This consists of a number of printing units on which both sides of the web are imprinted with the various colour components of the multi-colour design to be printed. The web is payed off from a reel at constant tension and fed via a multitude of guide rollers to the printing units. At the end of the machine several webs may be run together in the folding apparatus where they are cut, stitched and folded. The high printing speed (up to approx. 450 m or 1,480 ft/min in the case of intaglio or rotogravure printing and up to approx. 650 m or 2,130 ft/min with letterpress printing) and the long web travel (up to approx. 15 m or 49 ft per printing station) present difficult control problems for the synchronisation of the individual plate cylinders [1].

By reason of their high production speed, modern printing presses are able to print immensely large numbers of copies within a very short time. In order to increase the utilisation of the machines, they are used for printing several programmes at the same time. Clutches in the common drive shaft make it possible to adapt the press to the different printing programmes. If the drive power is also subdivided and a separate drive motor is assigned to each group of printing units or to each printing station, the machine can be readily adapted to the desired printing programme in a manner similar to a system designed on the unit principle. Fig. 2 shows the arrangement of the machine for two production conditions. In the top illustration all printing stations are coupled together to enable an extensive multi-colour programme to be printed. In the lower illustration the press is sectionalized, each section operating with a shorter programme, independent of the other, and feeding into one of the two folders.

The drive motors operate onto the main shaft via Veebelts or mitre gears; they may also be built directly into the main shaft. Their ratings are between 20 and 100 kW. Since all motors are rigidly connected with each other when the main shaft is connected through, appropriate measures have to be taken to ensure that the load torque is uniformly shared between all motors. Variable-speed motors do not fulfill this requirement automatically.

Fig. 1 Operating front of a rotogravure printing press

Since at the beginning of a run or after a break, the web is still frequently threaded by hand into the printing stations and folder it is not possible to make any appreciable increase in the threading speed. This condition gives rise to an ever increasing speed range. Formerly, this problem was solved by employing an auxiliary motor and an overriding clutch; however, this arrangement is nowadays seldom used. Modern machines are designed with a main drive the speed of which can be continuously regulated over a range of 1 : 50 or even as high as 1 : 100, that is, practically from standstill upwards. With this, particular importance is attached to a constant threading speed. When the mains voltage falls, for example, or the impression cylinders are lowered onto the plate cylinders, the speed should not drop appreciably; on the other hand, the threading speed must not suddenly



Top : Machine coupled through to form one unit: one programme with two paper reelsf eeding onef older
Bottom : Machine sectionalized for two programmes with a single paper reel feeding each folder

Fig. 2 Schematic arrangement of a rotogravure printing press

increase since this would give rise to the danger of operating personnel being caught in the machine.

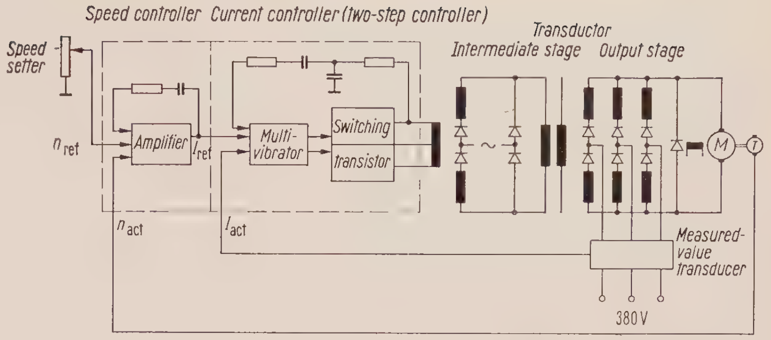


Fig. 3 Transductor-fed drive with transistorized control

Transductor-fed drives

The development of the rotary printing press drives led from d. c. machines with rheostatic control of armature and field via three-phase slipring induction motors to three-phase commutator motors with shunt characteristic which have found wide-spread application in recent years. In addition to these, variable-speed d. c. motors with armature voltage control have come into the foreground in the last few years. The d. c. motors are fed via Ward-Leonard motor-generator sets, mercury-arc converters or transductors, with controlled semi-conductor elements envisaged for future use. Ward-Leonard sets and mercury-arc converters are generally more economical for feeding motors in large plants with a high-voltage supply, provided the machines are mainly operated with a definite programme. In this case, one or two busbar systems are provided to supply the motors; furthermore, in cases where the droop of the performance characteristics of the motor is not sufficient, field control or buck and boost generators are used to provide uniform load sharing.

For machines the clutches of which have to be operated frequently, this method often becomes too expensive. The use of transductors will then be more economical. Transductors are available in a closely stepped type range from approximately 10 to 300 kW for all regulating ranges. They can therefore be fairly well adapted to the motor outputs. The advantages offered by transductors such as a simple, stationary construction without heavy foundations, low maintenance requirements, insensitivity to temperature variations and to chemically active atmospheres (hermetically sealed silicon rectifiers), are also reflected in the printing press drives themselves.

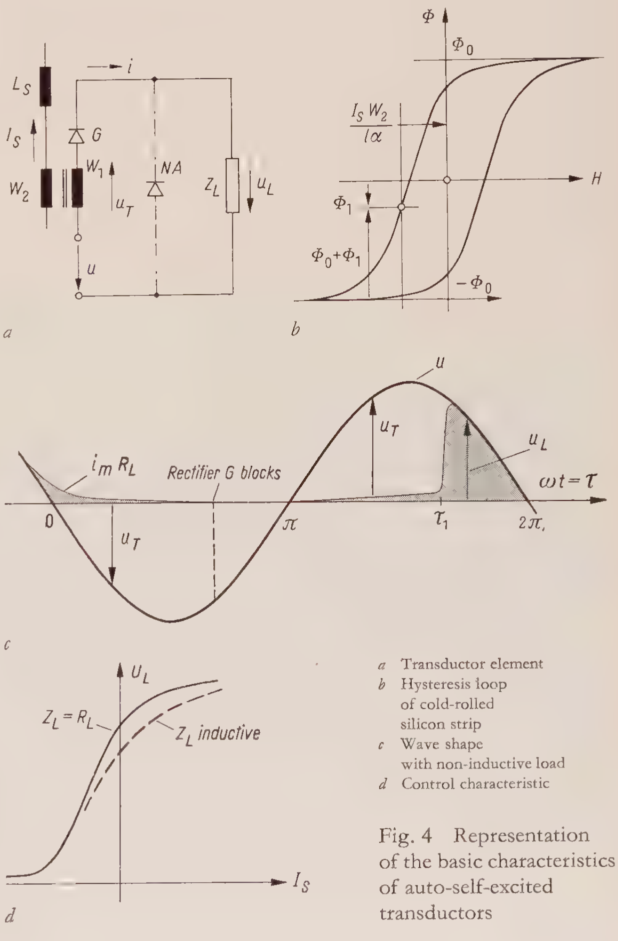
During running, the torque is mainly constant, and there are no load surges. Since the direction of rotation is fixed and since, after starting, operation continues at constant speed, single-quadrant control ($U_a > 0, I_a > 0$), as offered by the transductors, is sufficient.

If the web breaks, the press must be stopped quickly, either by inserting resistors or by means of mechanical brakes. The dependency of the motor speed on the mains voltage at a low transductor output voltage and the response time of the transductor-fed drive can be easily compensated by quick-acting controllers.

For drive outputs of more than 10 kW, the transductors are arranged in three-phase bridge connection with bypass anode for six-pulse operation, as shown in Fig. 3. With a residual voltage drop of 15 to 20% at the transductor elements and with a direct power supply from the 380-V mains system, a d. c. voltage as high as about 420 V can be attained. Since with six-pulse operation the harmonic content of the armature current of the motor is low, no further smoothing is required apart from the inherent filter action of the armature reactance [2].

The mode of operation of auto-self-excited transductors is well known. The basic characteristics of the device will, however, be briefly explained by way of a very simple model (Fig. 4).

Fig. 4*a* shows an a.c. voltage source u in series with an impedance load Z_L and a transductor element consisting



a Transductor element
b Hysteresis loop of cold-rolled silicon strip
c Wave shape with non-inductive load
d Control characteristic

Fig. 4 Representation of the basic characteristics of auto-self-excited transductors

of a rectifier G and a reactance coil W_1, the iron core of which has an approximately square-shaped hysteresis loop (Fig. 4*b*). The hysteresis loop is characterized by a very steep magnetising range, providing almost complete saturation at 0.1 to 1 A/cm. Such properties are found in nickel or silicon-alloyed steels which have been subjected to extensive cold working. The transductor model is controlled by a second winding W_2 through which a variable impressed direct current I_S is driven. This is indicated by the control reactor L_S. Fig. 4*c* shows the mode of operation with a non-inductive load $Z_L = R_L$. During the control half-cycle $0 < \tau < \pi$ the core is "set". The induced voltage $|u_T| > |u|$ at first causes the rectifier to remain conductive against the effect of the mains voltage u. However, only a very low magnetising current flows, causing a negligible voltage drop $i_m \times R_L$ across the non-inductive load R_L. As soon as the magnetic flux in the magnet core has reached the limit value Φ_1 on the falling curve, which is fixed by the control current (Fig. 4*b*), the current ceases to flow through the load winding W_1 and the rectifier becomes non-conductive. The magnetic state of the core remains unchanged until the instant when the mains voltage passes through the next zero. At the beginning of the output half-wave $\tau = \pi$, the transductor winding W_1 again absorbs the full mains voltage, while the magnetic flux in the core approaches the saturation value Φ_0. As soon as the flux reaches the value Φ_0, the voltage u_T across the winding W_1 decays to a small value; the mains voltage appears across R_L and causes a load current to flow which is a multiple of the magnetising current. When, at the end of the output half-wave, u again becomes negative, the magnetic flux of the transductor element core returns to its control interval $\Phi_1 < \Phi < \Phi_0$ and a new control cycle begins.

Part of the positive half-waves of u thus appear at the load resistor; their cut-off point τ_1 is determined by the flux interval $\Phi_0 + \Phi_1$, i. e. the control current I_S. If the winding W_1 is designed for the full half-wave value of the mains voltage, the mean value of the load voltage

$$U_L = \frac{1}{2\pi} \int_{\tau_1}^{2\pi} u_L \, d\tau$$

becomes proportional to the unused flux range $\Delta\Phi = \Phi_0 + \Phi_1$ of the core loop for each value of the control current I_S. The control characteristic of the transductor U_L (I_S) (Fig. 4*d*) therefore approximately reproduces the left-hand curve of the hysteresis loop Φ (I_S) of the transductor element core.

The load resistor hardly affects the reverse cycle of the transductor. The control characteristic therefore depends upon R_L only via the internal resistance of the transductor (steepness of hysteresis loop in the saturation range, winding resistance). With another load of the transductor, say an inductive Z_L, the control characteristic is slightly distorted. Since, as a result of the inductive load, the load current i_L cannot suddenly jump up to the value of the magnetising current when the mains voltage passes through zero at $\tau = 2\pi$, each positive voltage pulse across the load impedance is followed by a smaller negative pulse which reduces the mean value U_2 for a given control current (Fig. 4*a*). The original characteristic can, however, be re-established by providing the by-pass anode NA indicated in Fig. 4*a*.

In the case of a load with a back-e.m.f., the control characteristic lies higher than in the case of a non-inductive load, since a load current flows only as long as the mains voltage is higher than the back-e.m.f. With a limited number of phases, as in the simple example selected, the transductor output depends to a high degree on the load. This results from the fact that the point where the current ceases to flow ($\tau = 2\pi$ for $Z_L = R_L$) and also the point where it sets in depend on the magnitude of the back-e.m.f. in a manner similar to a rectifier which feeds into a filter circuit having an input capacitance. When the transductor is loaded with a motor the two effects occur simultaneously as a result of the back-e.m.f. and armature reactance of the motor [3].

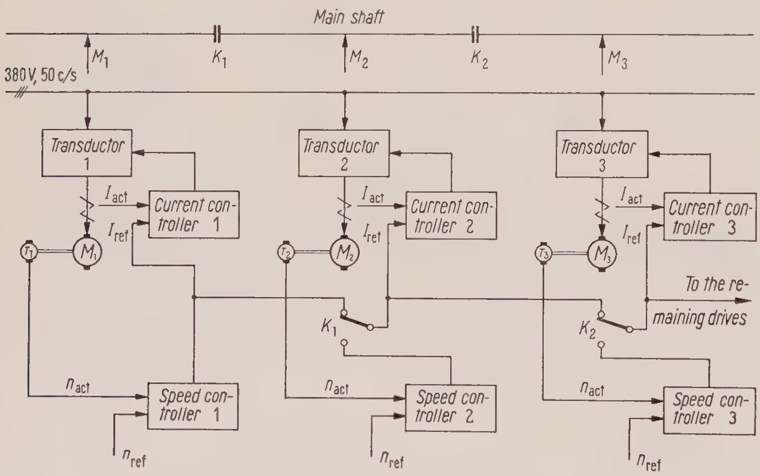


Fig. 5 Basic circuit arrangement of a rotary printing press drive with transistorized control

From this simple example can be derived some of the basic properties of the transductor which also obtain in complex circuit arrangements:

1. Due to the effect of the rectifier, $i_L = 0$ and hence $I_L = 0$.
2. Due to the effect of the reactor, $U_L > 0$.

   This rule results from Kirchhoff's network law. Since in steady-state operation the d. c. voltage across the reactor is zero, the d. c. component of the load voltage must be counterbalanced by a corresponding d. c. voltage across the rectifier or

valve. With non-controlled valves this is only possible in the reverse (blocking) direction. This precludes magnetic inverter operation with non-controlled values.

3. A by-pass anode eliminates the effect of an inductive load on the characteristics of the transductor and improves its power factor.
4. The minimum output current of the transductor is determined by the magnetising current of the reactors.
5. If the leakage current of the rectifiers approaches the magnitude of the magnetising current, the amplification is reduced since the core is demagnetized beyond the cut-off point Φ_1.

Control of drives operating in parallel

One of the main difficulties involved with sectional drives is the load sharing between the drive units connected to the main shaft. The loads or torques which are required by the individual printing units are by no means equal in magnitude; they depend, for example, on the plate composition or the pressure of the impression cylinder as well as on the mechanical and thermal condition of the machine. The ideal case would be obtained if each section coupling between two machines were stressed by a compensating torque of constant direction, which eliminates the mechanical play of the clutches. This would improve smooth running of the machine and maintenance of correct register in multi-colour printing. Up to the present no simple measuring devices are available for the operational detection of the compensating torques. For this reason, a compromise is made by sharing the total load between all motors in proportion to their rating. This, however, invariably leads to fluctuating compensating torques in the section couplings.

The simplest method of obtaining satisfactory distribution of the load is to employ motors having a drooping speed characteristic (series characteristic). Small differencis in the motor characteristics only result in small differences in the motor torques. Speed control, especially in threading, is, however, made more difficult. With shunt-characteristic motors, including transductor-fed ones, parallel operation of a number of motors onto a common drive shaft presents certain difficulties, even if the coordinated transductors feeding the motors are controlled from a single master controller. Slight differences in the control characteristics or motor fields would result in a greatly varying distribution of current and torque between the section motors, so that some of the motors would operate near the current cut-off while others would possibly operate at zero current. With load sharing, current control is therefore an absolute essential.

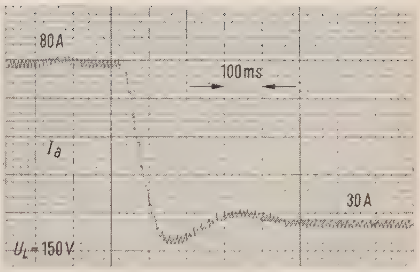


Fig. 6 Step function response of the current control system of a transductor-fed drive upon a disturbance of the desired value

A modification of the principle of multi-loop control systems (transistor control) [4] is particularly expedient; here, the individual continuous-action current controllers are provided with reference input signals from a single master speed controller. The speed controller evaluates the speed deviation of the drive shaft and supplies each of the current controllers with the respective reference current value. This permits satisfactory load sharing between any number of section motors. A simple method of current limitation is obtained by limiting the output voltage of the speed controller to an adjustable value which represents the reference input signal for the current controller. The other advantages of this control principle as applied to transistorized controls, e.g. the simple design of the controllers or the ease with which the motors can be put back into operation after separation of the individual control systems, are fully retained. Fig. 5 shows the control scheme for the first three sectional drives of a printing press. Each motor is fed via a transductor. A speed controller is additionally assigned to each motor which, depending on the set-up of the printing press, may become a master motor. The connection I_{ref} indicated in Fig. 5 simulates the main shaft shown. If the machine is operated as a complete unit, i.e. all

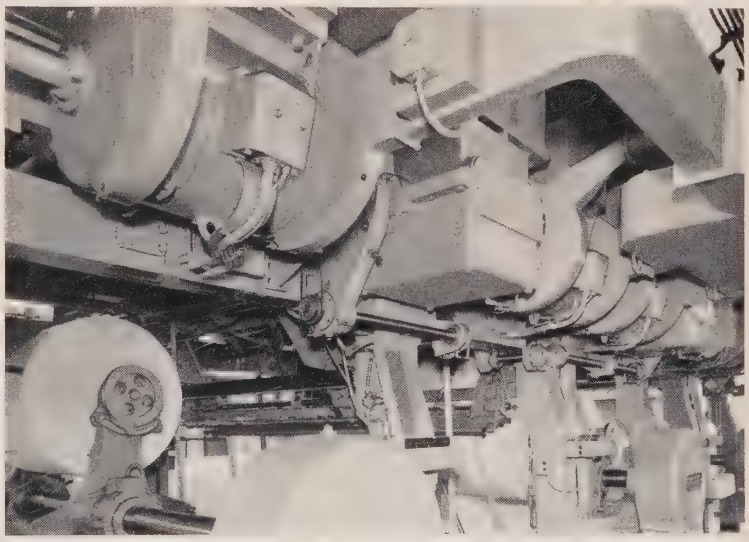


Fig. 7 View of the drive motors of a letterpress rotary printing machine with twelve 45-kW motors

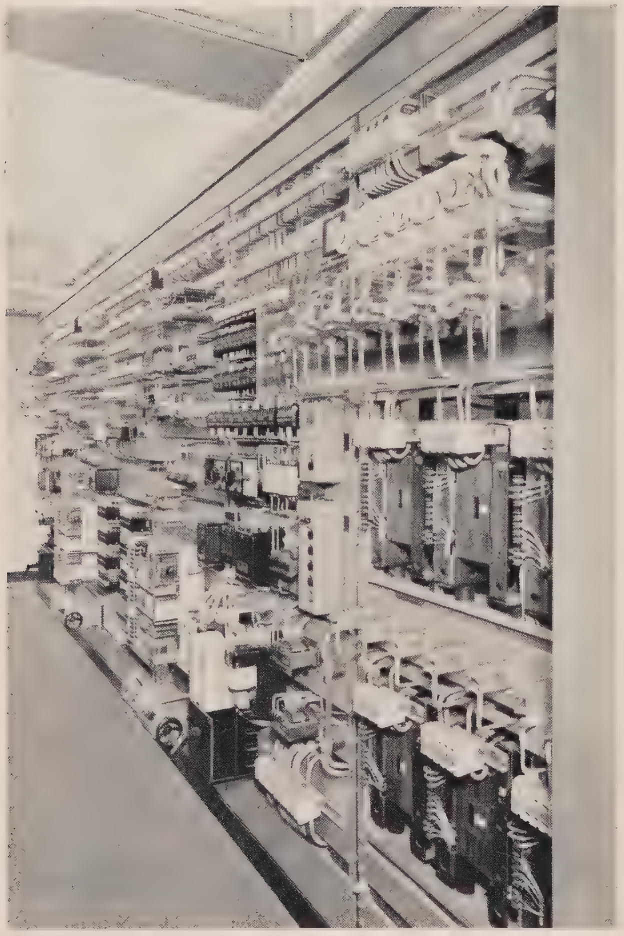


Fig. 8 Operating and controller panels of a transductor-fed d. c. sectional drive

section clutches are engaged, the contacts K_1 and K_2 are in the position shown in the diagram. Motor 1 then acts as the master motor; its speed controller provides the reference current values and all remaining speed controllers are made inoperative. If the machine is sectionalized, each motor arranged to the right of a disengaged clutch acts as master motor for the respective group of drives.

The set-up of such control systems has been dealt with in detail elsewhere [4,5]. The subordinate current control system (see Fig. 3) comprises the transistorized current controller, the single-phase magnetic pre-amplifier (which can be omitted for motor outputs up to about 40 kW), the three-phase power transductor, the armature of the motor and a measured-value transducer which converts the armature current, i. e. the transductor input current, into a potential-free voltage signal (current transformer, transductor or Hall generator). The current controller is built up of transistorized sub-assemblies. An amplifier in multivibrator connection is used as the timer of a push-pull output stage for switching operations (two-step controller) [6]. The transient characteristics of the controller are determined by its four-pole negative-feedback element. The current controller is generally of the PID (proportional plus integral plus derivative action) type. The high quality of current control is characterized by the fact that, on loss of excitation of one of the motors operating at full rated speed, the current of this motor exceeds only slightly the currents of the sound motors under steady-state conditions.

The speed controller contains a continuous-action transistor amplifier which is given a proportional plus integral action by means of the feedback element. The speed is measured directly by means of a tachometer generator or indirectly via the e. m. f. induced in the motor.

The use of these electronic controller sub-assemblies in conjunction with ample overcontrol in the input and power transductor makes for very short correction times. Fig. 6 shows as an example a current step function response of a 45-kW transductor-fed drive upon the disturbance of the desired value. With an input amplifier time constant of 30 ms, a power amplifier time constant of 300 ms, and an armature time constant of 30 ms the response time for the current is approx. 60 ms.

Figs. 7 and 8 show sections of an installation on a letter-press rotary printing machine with twelve 45-kW d. c. motors, which are mounted underhung to the top of the base structure (Fig. 7). The main shaft is made up of the armatures of the section motors. The printing units and folders arranged above are driven via interposed mitre gears. The motors are supplied with fresh air from a centralized ventilation system to prevent the entry of paper dust and print vapour. The power transductor and regulating and control devices are located in a separate room. Fig. 8 shows the equipment for two drive units. The control panel is arranged in line with the reactor and rectifier panel. The following panel accommodates the transistorized controllers [7] and the intermediate magnetic amplifiers. A sectionalizing panel connects the two adjacent drive groups.

The transductor-fed d. c. drive has thus assumed a major role in meeting the stringent requirements made with respect to the control accuracy of rotary printing presses.

Bibliography

[1] Anke, K. and Preis, W.: Die Siemens-Registerregelung. Siemens-Zeitschrift **34** (1960) pp. 75 to 83

[2] Kümmel, F.: Verhalten von Magnetverstärkern bei Motorbelastung. ETZ-A **80** (1959) pp. 344 to 349

[3] Leonhard, W.: Speed Control of a D-C Motor using a Magnetic Amplifier. Trans-AIEE **76** (1957) pp. 112 to 119

[4] Ströle, D. and Vogl, H.: Transidyn-Regelungen für Walzwerksantriebe. Regelungstechnik **8** (1960) pp. 194 to 201

[5] Offer, U., Watzinger, H. and Zabel, R.: Transduktor-Gleichstromantriebe mit Transidyn-Regelung. Siemens-Zeitschrift **34** (1960) pp. 648 to 652

[6] Keßler, C.: Ein Transistor-Zweipunktregler. Siemens-Zeitschrift **31** (1957) pp. 505 to 509

[7] Neuffer, I. and Wiangke, K.: Ein Einschubsystem für Transistor-Bausteine der Regelungs- und Steuerungstechnik. Siemens-Zeitschrift **34** (1960) pp. 708 to 711

Radiotelegraphy

By Hans Heinrich Voss

The diversity of the transmission characteristics of radio frequencies and the various methods by which they can be utilized has resulted in the development of a large variety of equipment for different frequency allocations and applications. The present paper reviews the principal techniques used in radiotelegraphy and briefly describes the equipment with which radiotelegraphy links are established.

General

Telegraph messages are composed of extremely simple code signals, a few discrete steps of an electrical quantity being transmitted in the form of pulses of equal length over a line or radio path. In the simplest and by far the most important case, only two different states (binary signal) are used. These may be denoted by 0 and 1 (mark and space) and correspond electrically, for example, to the following pairs of states: current/no current (neutral operation), positive/negative (polar operation), and, in the carrier range, to off/on (amplitude modulation) or to two different frequencies (frequency modulation) or even two different phases (phase modulation) of a carrier wave (Fig. 1).

In the early days of radio engineering, telegraph messages were transmitted simply by switching the carrier off and on. Recourse was here taken to the familiar morse code, which is still used in marine radio, ham transmissions and other applications. The majority of telegraph traffic today, however, is conducted between teleprinters, which themselves encode and decode the transmitted characters (letter, numeral, etc.).

As each character is represented – in the case of the Five Unit Code (Fig. 2), for instance, – by binary signals composed of five pulses, a total of $2^5 = 32$ different characters (CCIT Alphabet No. 2) results. This is sufficient for the transmission of letters, numerals and other conventional symbols in so far as two of the code signals are used for switching the receiving teleprinter from LETTERS to FIGURES and back. Each signal of the Five Unit Code is preceded by a start element for switching on the motor of the teleprinter and succeeded by a stop element that shuts down the motor again. As the pulse duration is $T = 20$ msec (telegraph speed $v = \dfrac{1}{T} = 50$ bauds), up to 400 characters can be transmitted per minute.

Large teleprinter networks operating on this principle have been established in most countries alongside the telephone networks. Teleprinter patrons dial each other direct (telex). One of the more recent problems that have had to be solved by telegraph transmission engineering has been the interlinking of the networks of different countries by radio paths, many of which have to span vast distances (worldwide telex, Fig. 3). A solution was first made possible by the application of new

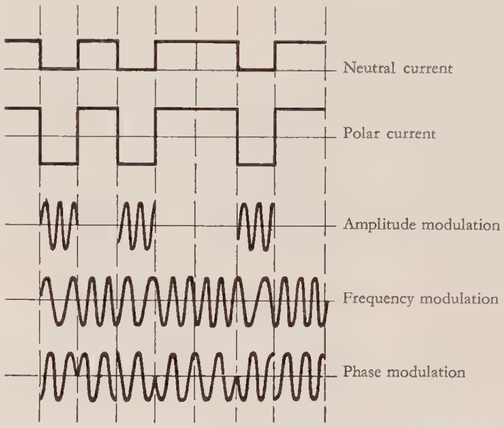


Fig. 1 Types of modulation for radiotelegraph transmission

Figs	Ltrs	CCIT No. 2	CCIT No. 3
-	A	●●○○○	○○●●○●○
?	B	●○○●●	○○●●○○●
:	C	○●●●○	●○○●●○○
Who are you	D	●○○●○	○○●●●○○
3	E	●○○○○	○●●●○○○
%	F	●○●●○	○○●○○●●
	G	○●○●●	●●○○○○●
	H	○○●○●	●○●○○●○
8	I	○●●○○	●●●○○○○
Bell	J	●●○●○	○●○○○●●
(	K	●●●●○	○○○●○●●
)	L	○●○○●	●●○○○●○
.	M	○○●●●	●○●○○○●
,	N	○○●●○	●○●○●○○
9	O	○○○●●	●○○○●●○
0	P	○●●○●	●○○●○●○
1	Q	●●●○●	○○○●●○●
4	R	○●○●○	●●○○●○○
'	S	●○●○○	○●○●○●○
5	T	○○○○●	●○○○●○●
7	U	●●●○○	○●●○○●○
=	V	○●●●●	●○○●○○●
2	W	●●○○●	○●○○●○●
/	X	●○●●●	○○●○●●○
6	Y	●○●○●	○○●○●○●
+	Z	●○○○●	○●●○○○●
CR		○○○●○	●○○○○●●
LF		○●○○○	●○●●○○○
Figs		●●○●●	○●○○●●○
Ltrs		●●●●●	○○○●●●○
Space		○○●○○	●●○●○○○
		○○○○○	○○○○●●●
Idle signal α			○●○●○○●
Idle signal β			○●○●●○○
RQ signal			○●●○●○○

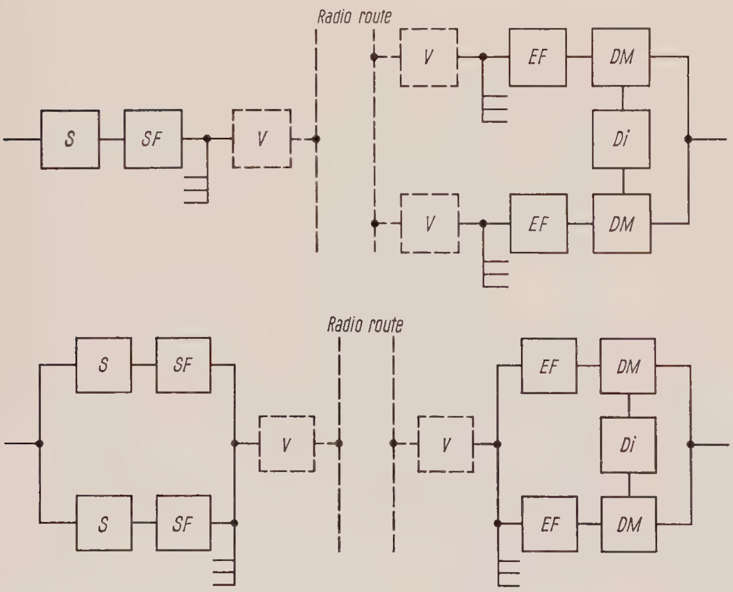
○ Start-polarity current (−)

● Stop-polarity current (+)

Fig. 2 Telegraph codes

Fig. 3 Worldwide telex network

concepts and equipment. Two of the essential features here involved are the simple storage of binary signals and error detection with the aid of more complex codes.



S FM transmitter
SF Send filter
V Amplifier
EF Receive filter
DM Demodulator
Di Diversity combiner

Fig. 4 Examples of application of space diversity (top) and frequency diversity (bottom)

Along with the transmission of characters in the Five Unit Code by teleprinters, the transmission of information on the Hell principle and facsimile transmission are also of importance.

In the case of the Hell technique the printed characters are decomposed in a simple manner into picture elements and the individual elements transmitted in succession and reconstituted at the receiving end in printed form.

Facsimile techniques serve for the transmission of drawings or written information, weather charts, etc. The document to be transmitted is placed on a drum and optically scanned in a spiral at a low speed. Pulses are generated as a function of the degree of blackness and converted into electrical signals that are transmitted to the receiving station, where they produce a printed record of the information transmitted. The recording paper is placed on a drum in the same way as the document at the transmitting station and the drum is advanced at the same rate.

Techniques

Numerous transmitting techniques have been developed over the years. Current

methods for the reliable and efficient transmission of telegraph signals over radio paths disclose, however, a distinct trend which is characterized by and large by the following features:

Frequency modulation

The carrier for a telegraph channel is frequency-shifted between two closely positioned values in correspondence with the two distinctive states of the signal.

Diversity techniques

If frequency modulation fails to secure reliable transmission in the case of information that has to be received by a single station, recourse is taken to diversity operation (Fig. 4). Use is here made of the observation that, if two antennas are installed sufficiently far apart (space diversity), the signals will be received by at least one of the two without interference. A similarly successful solution is arrived at by transmitting the same information with two carriers of different frequency (frequency diversity).

Protected codes

In cases where the incidence of errors in transmission is still too great in spite of the above measures, recourse is taken to more complex codes that permit error detection. Error detection is not possible with the Five Unit Code because all the 32 possible code permutations are here assigned. However, if a Seven Unit Code (Fig. 2) is adopted and only those 35 permutations of the possible $2^7 = 128$ are used that contain, for instance, three stop-polarity pulses and four start-polarity pulses, any incoming signal that does not conform to this 3:4 ratio may be concluded to be false.

Synchronous systems

If two intercommunicating telegraph transmission terminals operate in synchronism, the transmission of start and stop pulses is not necessary. Faults which might otherwise cause the undesired starting or stopping of the receiving teleprinter as the result of the falsification of a start or stop pulse during transmission over the radio paths are in this way completely avoided. Owing to the higher outlay for the equipment, synchronous transmission is normally only used where it is required for other reasons as well. This will, for instance, be the case with a system operating with the Seven Unit Code and automatic request (ARQ) on account of the necessary timing of the repetition process.

Multiplex techniques

If several messages have to be transmitted in independence of each other over a radio path, an a-f carrier will, in the simplest case, be frequency-shifted for each message. As the transmission of a telegraph message requires the use of only a narrow frequency band, a speech band such as that available for radiotelegraph communication (0.3 to approx. 3 kc) is able to accommodate a large quantity of telegraph channel frequencies arranged next to each other. This practice is known as the frequency-division multiplex technique (v-f telegraph-system).

In the case of synchronous systems, several channels are usually interleaved with respect to time, this being known as the time-division multiplex technique (Fig. 5). Two transmissions are here combined, with the telegraph speed doubled. The characters of the two messages are paired off, a character of one message being transmitted following a character of the other message and so on in alternate sequence. If the telegraph speed is once again doubled, two such pairs can be combined in time by, say, transmitting the individual code pulses alternately. It is not advisable to combine more than four 50-baud channels in this way.

Combination of time-division multiplex and frequency-division multiplex

As it is not advisable to combine more than four telegraph channels in the case of time-division multiplex operation, recourse is taken to a combination of time-division multiplex and frequency-division multiplex in applications where the combination of more than four channels is required. To multiplex a sideband of a radio telephone transmitter, for instance, it is common practice first of all to combine four channels on the time-division multiplex principle. If the Seven Unit Code is adopted at the same time, this results in a telegraph

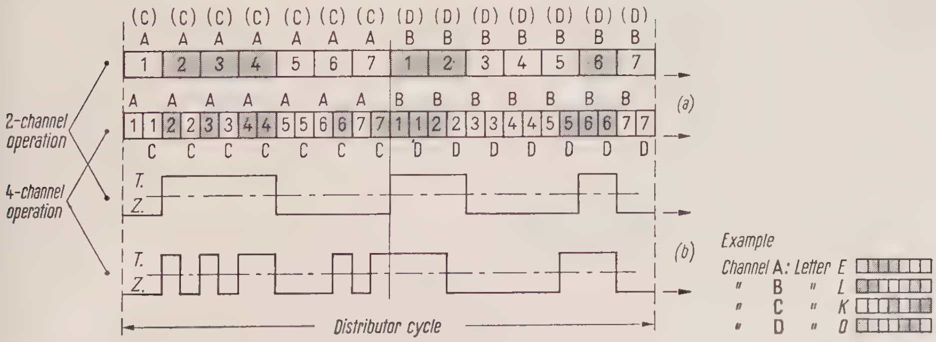


Fig. 5 Interleaving of code pulses with 4-channel time-division multiplex technique (Mux)

speed of almost 200 bauds. A frequency band of 500 cps is quite large enough for the transmission of composite information in this form. By using the frequency-division multiplex technique it is therefore possible to operate several such groups of 200-baud channels at adjacent frequencies over an SSB radio path. This mixed combination of channels has already been the practice for several years in long-haul and, in particular, transcontinental traffic.

Radiotelegraph transmission equipment

There is today a large variety of different types of transmitting equipment. There are two reasons for this. One is that, except for the medium waveband that is reserved for standard broadcasting, all wavebands are available for radiotelegraphy and the transmitting equipment thus has to be adapted to the characteristics peculiar to these wavebands. The other is that, as in the shortwave band, for instance, the equipment used differs according to the distance to be crossed, the specified frequency stability, and handling requirements. The wavebands used for telegraphy may be roughly classified as follows:

LF	30 to 300 kc
HF	3 to 30 mc
VHF	30 to 300 mc
UHF and SHF	300 to 30,000 mc

LF transmitting equipment

Longwaves have a large range of propagation. Fading is infrequent, but a great many disturbances are to be expected. Directivity suffers on account of the great wavelength.

The principal frequency range assigned to telegraphy is that between 50 and 140 kc. Owing to its relatively good propagation conditions, this range is particularly suitable for the radio coverage of large areas from a centrally located transmitting station. For this reason news agencies, for instance, transmit their reports in the longwave band in the form of F1 telegraph messages. German and several other weather stations also use the longwave band (at around 100 kc) for transmitting their weather maps by F1 facsimile.

For the reception of such information Siemens & Halske have introduced a longwave receiver for the frequency range from 45 to 145 kc (Fig. 6) which has been designed with major emphasis placed on operating stability and simple handling. The receiver comes in two models adapted in bandwidth to the respective requirements of telegraph or facsimile transmission. Operating with crystal resonators, the receiver exhibits such great frequency stability that it practically never has to be readjusted once it has been placed in service. To adapt it to another receiving frequency only a few hand motions are required after changing the crystal.

HF transmitting equipment

Shortwaves are particularly suitable for crossing great distances, this being due to their reflection at the ionosphere. Radio links can here be established without difficulty for telegraphy and, in particular, transoceanic telegraphy.

Although the continuous changes in the structure of the ionosphere present considerable difficulties to shortwave transmission, these can be overcome by the choice of a frequency suited to the particular time of transmission, by diversity operation, and, in many cases, by the use of equipment featuring error detection and ARQ. By these measures it is possible to secure the same high transmission performance for shortwave telegraphy as for telegraphy over cable systems.

Shortwave transmitters can be roughly classified as large type or small type. They differ from each other in transmitting power, size and, as a rule, also in versatility, ease of handling and specifications. In the present paper these transmitters can be treated only briefly.

Shortwave transmitters designed for telegraphy alone are provided with facilities for F1 (frequency-shift) and F6 (twinplex) keying with which two telegraph messages can be transmitted simultaneously by shifting between four frequency positions. The appropriate

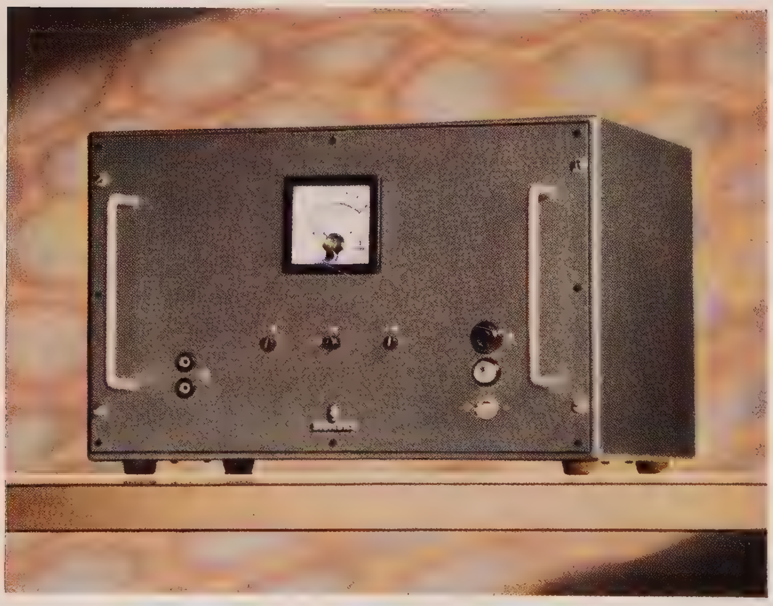


Fig. 6 Longwave telegraph receiver

receivers are equipped with facilities for the demodulation of such transmissions. It is naturally also possible to use any radio receiver adapted to this waveband. As conventional radio receivers are not equipped for the demodulation of F1 emissions, a special adapter has to be added. The FSE 30 radiotelegraph receiver adapter seen in Fig. 7 has been specially developed for the Siemens E311 shortwave receiver. It connects to the i-f output (30 kc). With a built-in converter stage it can, however, also be used for transmissions having a higher frequency position, and can thus also be assigned to other receivers as well. Modularization of the adapter makes it a versatile piece of equipment meeting specific requirements. In normal circumstances the message is available in the form of polar signals, neutral signals for the direct operation of a teleprinter, or of v-f signals for relaying over great distances. It can also be equipped for any of the following types of operation:

Diversity reception is possible by using two systems and an additional module. There is built-in automatic tuning control. Twinplex messages can also be received. All amplifiers are in the form of transistors.

For multiplex telegraph transmission recourse is primarily taken to shortwave radiotelephone transmitters and receivers adapted for SSB modulation.

The available speech channel is used by a v-f telegraph system, the individual telegraph channels operating with frequency modulation. This technique is extremely useful for combining telegraph channels and has proved its value in combination with diversity techniques over the past two decades. Backed by the experience so acquired, a new radiotelegraph transmission system has been developed which takes account of the current demands made on radiotelegraphy (Fig. 8). The equipment is modularized; all amplifiers are in the form of transistors. Telegraph channels with three different bandwidths are available, the spacing between channels conforming for all bandwidths to the 170 cps allocation plan introduced for shortwave operation. The following table lists the three systems and their respective transmitting specifications and applications:

Type of system	Channel spacing cps	Swing cps	Bandwidth cps	Telegraph speed normal bauds	Telegraph speed max. bauds	Application
WTK 170	170	±42.5	125	50	75	Normal telegraph operation
WTK 340	340	±85	250	100	150	Two-channel time-division multiplex
WTK 680	680	±170	500	200	300	Four-channel time-division multiplex

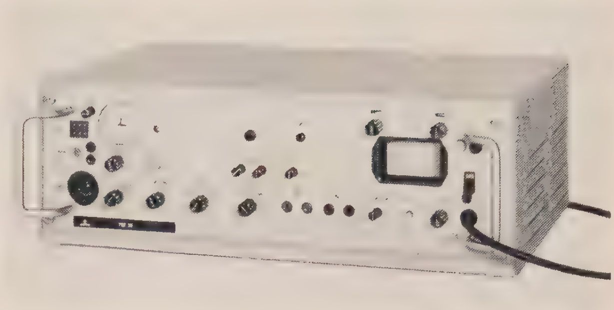


Fig. 7 Radiotelegraph receiver adapter

The telegraph transmission systems can be assigned channels of equal bandwidth or, if necessary, channels of nonuniform bandwidth. Various examples are shown in Fig. 9. They can also be used to secure the better utilization of radio feeder lines.

As an SSB link usually furnishes a bandwidth of 6 kc per sideband (corresponding to two speech bands), frequency converters are provided for the full utilization of such a band by v-f telegraph systems. These converters shift the band at the transmitting end from 0 to 3 kc to the range of 3 to 6 kc and in the reverse order at the receiving end. Frequency diversity may be used in the 6-kc band if required. In this case the same message is transmitted once over a telegraph channel in the range from 0 to 3 kc and again over a telegraph

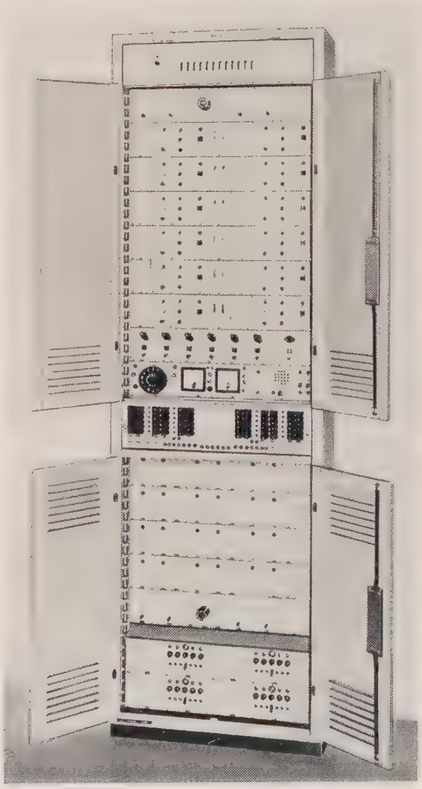


Fig. 8 Radiotelegraph transmission terminal for 12 send/receive channels, suitable for shortwave SSB links and radio feeder lines

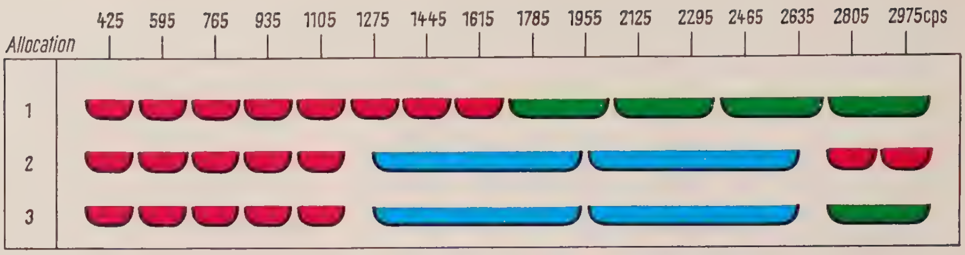


Fig. 9 Examples of frequency allocation for WTK 170/340/680 telegraph transmission system

channel in the range from 3 to 6 kc; the messages transmitted over the two channels are intercompared at the receiving end by a diversity combining and switching circuit; if any great difference in level is detected, the receive channel with the weaker signal is disconnected.

Message protection

The worldwide interconnection of national telex networks was first made possible by the introduction of radiotelegraph systems with error detection and ARQ. The equipment operates on the VAN DUUREN principle using the Seven Unit Code already mentioned. Whenever a character is detected to be false, an automatic request for repetition of the signal in question is transmitted. The Seven Unit Code contains three permutations more than the Five Unit Code; one of these is used as an ARQ signal and the other two (α and β) as

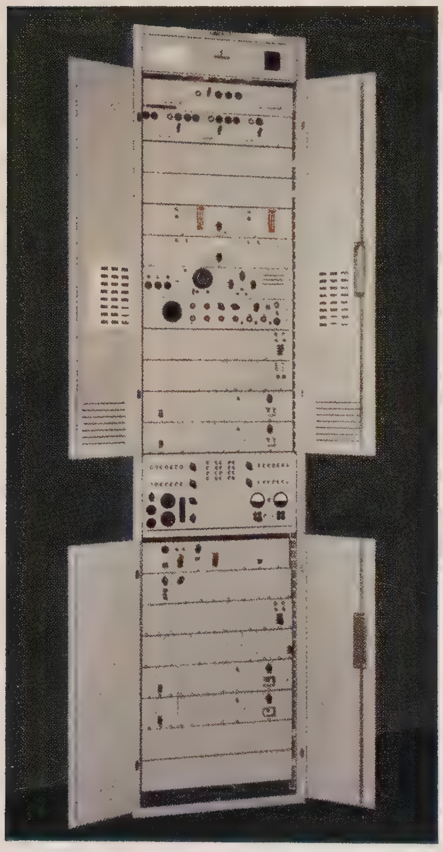


Fig. 10 Terminal with complete ELMUX 2/4 D7 radiotelegraph system

switching signals. One of the widest known systems of this type is the Siemens Mux 4 D 7a System for four-channel multiplex operation. Typing reperforators/transmitters and connecting units specially developed for this system enable it to be linked with national networks for international telex.

This system was superseded in recent years by the fully electronic Siemens ELMUX 2/4 D7 System (Fig. 10), which operates exclusively with transistors as switching and amplifying devices. Its distinctive features are modest space requirements, low power consumption and silent operation.

Transmitting equipment for VHF, UHF and SHF

The waves in these wavebands are readily focused and the large bandwidth available makes it possible for a radio path to accommodate a vast quantity of channels. These are already used in large numbers for telephony. There are no radiotelegraph systems specially designed for these wavebands; the speech channels are used for telegraphy through the provision of multichannel telegraph equipment. V-f telegraph systems originally developed for cable links can here in many cases be used. As the channel filters and receivers allow considerable level fluctuations the radiotelegraph transmission equipment previously described will be required only in anomalous cases where VHF transmission is subject to fading. Diversity operation is not usually necessary.

Bibliography

[1] Meinel, E. and Schröck, U.: Verfahren und Schaltungen zur Frequenzumtastung bei den modernen Funktelegrafiesendern. Der Fernmelde-Ingenieur **9** (1955) No. 7

[2] Kronjäger, W.: Die Übertragungsverfahren im Übersee-Funkdienst. Der Fernmelde-Ingenieur **9** (1955) No. 9

[3] Hennig, F.: Funkfernschreiben mit selbsttätiger Fehlerkorrektur. Nachrichtentechnische Zeitschrift **9** (1956) pp. 341 to 348

[4] Spiegel, H.: Störungsfreies Funkfernschreiben im Transatlantik-Verkehr. Elektro-Technik **39** (1957) pp. 261 to 264

[5] Croisdale, A. C.: Teleprinting Over Long-Distance Radio Links. The Post Office Electr. Engrs. Journ. **51** (1958) pp. 88 to 93 and 219 to 225

[6] Voss, H. H.: Eigenschaften von Telegrafie-Übertragungssystemen mit Frequenzmodulation bei Störungen durch Rauschen. Frequenz **12** (1958) Sonderheft October, pp. 31 to 37

[7] Neumann, H. J.: Wechselstromtelegrafiesystem für Kurzwellen-Telefonieverbindungen FM WTK 3/6. Nachrichtentechnische Zeitschrift **11** (1958) pp. 510 to 514

[8] Voss, H. H. and Neumann, H. J.: Telegrafieübertragung im Kurzwellenbereich. Nachrichtentechnische Zeitschrift **12** (1959) pp. 343 to 347

[9] Rudolph, H. and Bochmann, K. H.: ELMUX 2/4 D7 – an Electronic ARQ Multiplex Telegraph System. Siemens Review XXVII (1960) pp. 9 to 14

Operating Experience gained with Siemens Transistor Control for Mercury-arc Rectifier-fed Winders

By Hans-Joachim Henke and Ingemar Neuffer

The first rectifier-fed d.c. winders with transistorized control [1] were put into service in 1960. The control part of these plants consists of time and service-proved transistor subassemblies of the slide-in tray type [2]. In the following a report is given on the experience gained with the control of a twin-motor drive of 2×2.5 MW rated capacity during commissioning.

The motors are operated on the unit principle, i. e. each motor is arranged with its own rectifier set in anti-parallel connection. For light-load operation and in the event of faults on the rectifiers or motors the unit connection permits simple transition to single-motor operation. In the rectifier part of this plant by-pass anodes were used for the first time to reduce the reactive power during acceleration. The circuit arrangement for the grid control of the by-pass anodes can be kept simple if the by-pass anodes are switched on and off at the right time. On account of the step-like change in the control characteristic of the rectifier, the switching of the by-pass anodes increases the requirements made on the control of the winder motors. Each rectifier group is controlled by a wide-range transistorized grid control set [3] which makes it possible to take full advantage of the good transient characteristics of the mercury-arc rectifier.

Fig. 1 shows the arrangement of the power circuits and the transistorized control of the twin-motor drive.

Current Control

Each current controller acts on the cascaded control unit and therefore determines the voltage of its rectifier group. The current controllers are best set with the motor locked since in this case the relationship between armature voltage and current is governed only by the time constant of the armature circuit. Since the integral plus proportional action controller is adjusted to the symmetrical optimum [4] the recovery time of the current control circuit is generally determined by the duty cycle of the rectifier circuit. This makes for a favourable performance of the control system in the event of a disturbance of the variable desired value and for rapid control of load disturbances, which, for example, might result from the switching on and off of the by-pass anodes. Fig. 2 shows the effect of the by-pass anodes being cut into the circuit at a

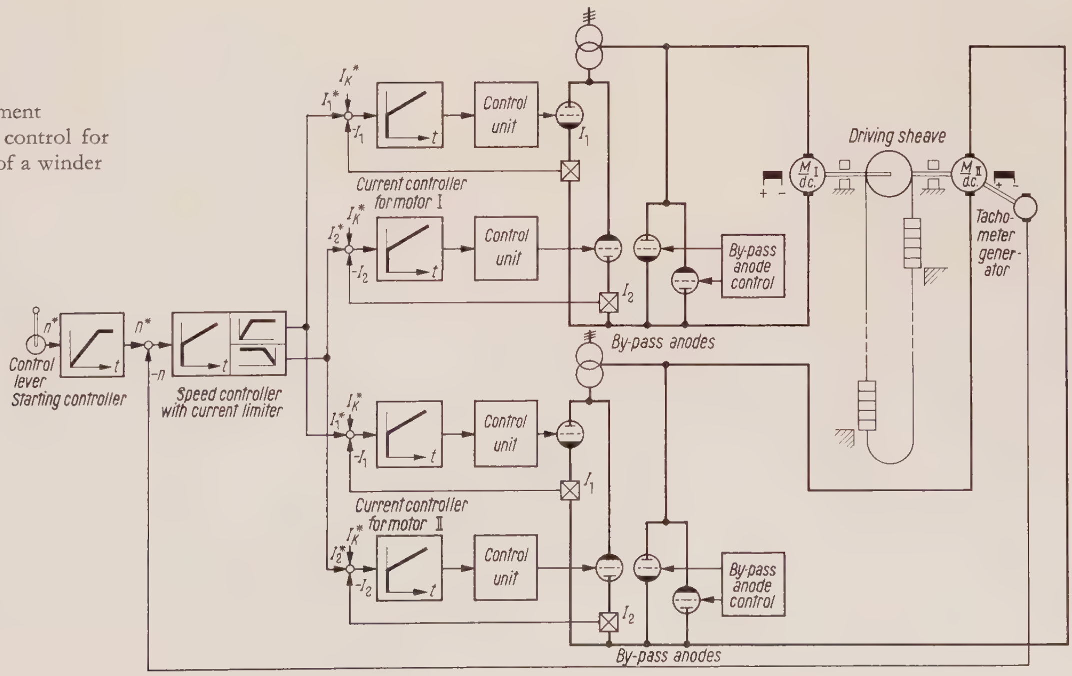


Fig. 1 Basic arrangement of speed and current control for the twin-motor drive of a winder

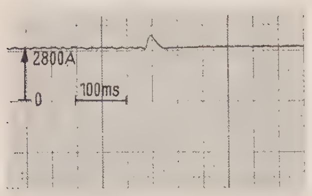


Fig. 2 Load disturbance of the armature current control on cutting in the by-pass anodes with the motor at standstill

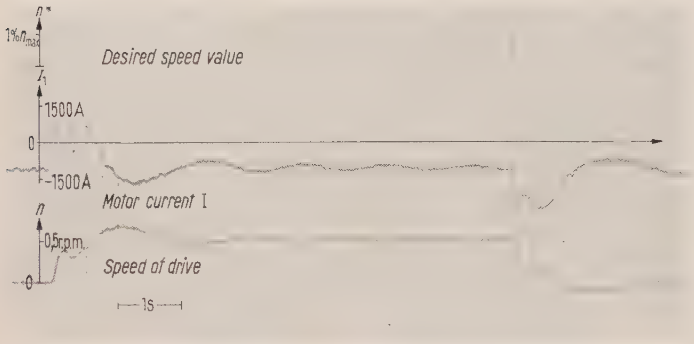


Fig. 3 Transient response of the speed control of a winder

constant armature current of 2,800 A. After approx. 30 ms the load disturbance is corrected, the maximum deviation of the armature current being about 500 A. In practical operation this current peak has no disturbing effect.

By limiting the desired value of the armature currents, the current is limited without causing overshooting. This measure protects the d. c. motors and rectifiers against overloads. Parallel operation of the two winder motors with their independent rectifier groups is attained in a simple way by applying the same desired value of current to both groups.

To ensure steady transition from positive to negative values of the armature current it is essential that the current-voltage characteristics of the anti-parallel rectifier groups should merge. This is achieved at minimum reactive power by a small circulating current which decreases with increasing motor current and which below a set value is completely suppressed.

Speed control

The speed controller converts the difference between the desired and actual speed available at its input into desired values for the armature current control circuits at its output. By keeping the output voltage of the speed controller within adjustable maximum limits, it is possible to limit the armature current.

The speed control can first be set before the hoisting rope is put on. The gain of the controller is thus adapted to the integration time of the drive (which governs the rise in speed at a constant armature current), the equivalent time constant of the closed-loop control circuit for the current and the amount of smoothing of the tachometer voltage.

After the hoisting rope has been put on, the cages are connected with the driving sheave through flexible steel ropes, the ropes and cages forming an oscillating system with a natural frequency of the order of one cycle per second. Sudden torque surges produced, for example, when the cages are loaded, initiate oscillations of the rope which, where the shaft losses due to friction and windage are low, are only slightly attenuated. Since in comparison with the oscillation frequency of the rope, the speed control is rapid, the gain of the speed controller may not be increased after the rope has been put on, in spite of an increase in the moment of inertia referred to the drive. The problem of rope oscillation has been studied on the Siemens control simulator [5] and this showed that a speed controller which controls out disturbances of the desired value rapidly but changes in load slowly has a damping effect on the rope oscillations.

Fig. 3 shows the response of the drive to a step change in the desired value of the speed. The cage which is loaded to 80% of its capacity tends to produce the same effect as the lowering of a load. The starting control process which is completed in approx. 150 ms is superimposed by rope oscillations with a frequency of 0.7 cycles which are controlled out by the speed controller as a load disturbance and decay in about 6 seconds.

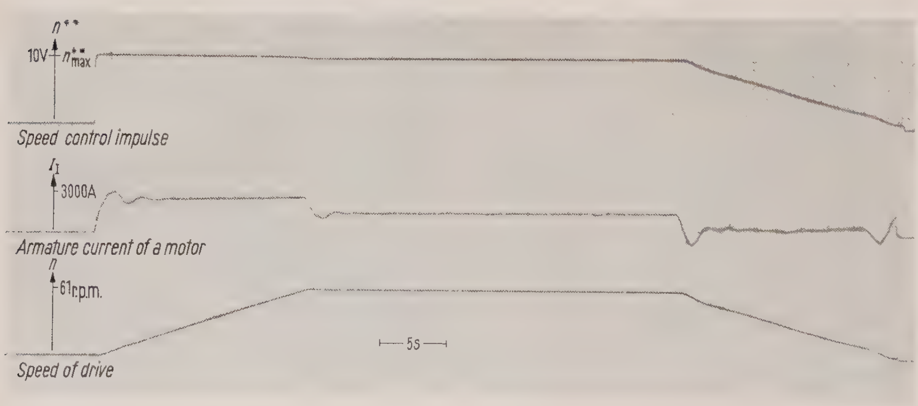


Fig. 4 Winding diagram for automatic operation

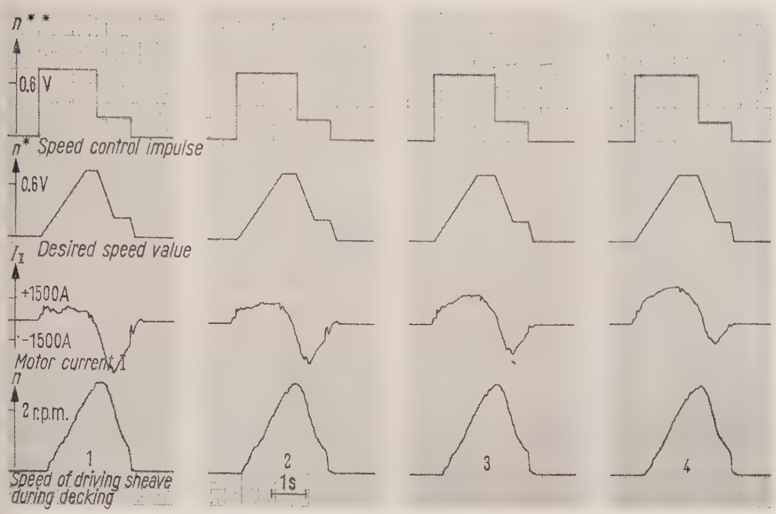


Fig. 5 Performance of control during automatic decking

Limitation of acceleration

The starting controller connected in series with the speed control circuit serves for starting with limited acceleration and for retarding the winder; it receives control impulses from the manual or automatic control gear. Under steady conditions the input signal is identical with the output signal. However, with a step change in the input voltage the starting controller transmits a desired speed value which increases linearly with time. Acceleration and retardation can be set independently as required.

Winding diagrams

Fig. 4 shows the speed variations during one wind in automatic operation. The rate of rise in speed is limited by the starting controller and braking is controlled by a cam disc arranged in the speed controller dependent upon the distance travelled. Changes in the acceleration give rise to transient rope oscillations which are indicated by the variation of the armature current. These, however, are caused to decay within about two cycles by the action of the speed controller.

During automatic decking, the starting controller receives the speed signals dependent on the position of the upper cage; the lower cage can only be guided via the rope which is of definite length. Just before the upper cage is level with the landing the service brake is applied, the speed control switched off and the driving sheave mechanically brought to rest. During the intervals between the individual decking operations (Fig. 5) the upper cage is unloaded and the full cars are at the same time pushed into the lower cage at the pit bottom. The current graph shows the change from suspended to rising load; the speed of the drive is, however, almost independent of the cage loads. For all decks decking periods of less than 3 seconds have been attained. Rope oscillations, especially those due to the lower cage, did not permit the setting of still shorter decking periods although the control system could have accommodated this.

The neat arrangement of the control equipment of the slide-in tray type which is assembled in functional groups makes it easier for the plant engineer to check and service the control and simplifies stock-keeping. Since they require only limited space, it was a simple matter to fit the controller cubicles into the rectifier plant (Fig. 6). The winder control built up of transistorized building blocks could be put into operation within a short time without giving rise to any difficulties.

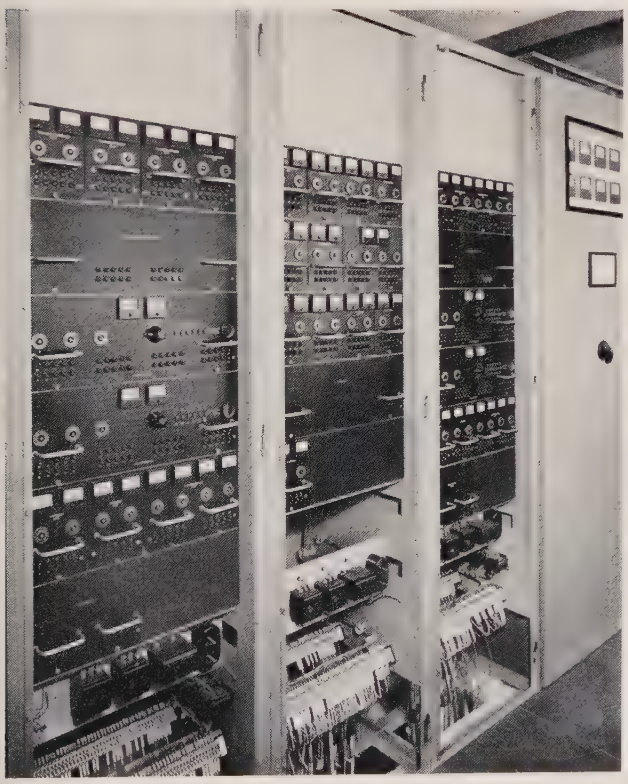


Fig. 6 Control equipment for the twin-motor drive of the winder

Bibliography

[1] Keßler, C., Meinhard, W., Neuffer, I. and Rube, G.: The D. C. Winder with Siemens Transistor Control System. Siemens Review XXVI (1959) pp. 234 to 240

[2] Neuffer, I. and Wiangke, K.: Ein Einschubsystem für Transistorbausteine der Regelungs- und Steuerungstechnik. Siemens-Zeitschrift **34** (1960) pp. 708 to 711

[3] Meissen, W.: Steuerung von Quecksilberdampf-Stromrichtern mit Transistor-Gittersteuersätzen. VDE-Fachberichte **20** (1958)

[4] Keßler, C.: Das Symmetrische Optimum. Regelungstechnik **6** (1959) pp. 395 to 400 and 432 to 436

[5] Anke, K., Keßler, C. and Ströle, D.: Das Regelmodell. Siemens-Zeitschrift **31** (1957) pp. 512 to 516

Siemens Wernerwerk für Weitverkehrs- und Kabeltechnik

By Albert Haag

With a view to establishing electrical long-range communications lines – a novel communications medium in those days – Werner Siemens founded in the year 1847 the Siemens Company, which was very soon to grow into an international organization. Europe's first electrical long-range communications network must be credited to his commercial drive, technical ingenuity and organizational talents: it was a radial network with Berlin as its center and Frankfort, Aachen, Hamburg, Stettin and Breslau as terminal points. Only a few years later he was also entrusted with the construction and maintenance of the Indo-European telegraph line running from London to Calcutta (almost 7000 miles), which even by present standards would still be regarded as a remarkable achievement.

It has always been one of the principal objectives of the Siemens organization throughout its 113 years of existence to develop long-range communications engineering to a point where, in both quality and quantity, it can economically meet the sharply rising traffic demands that are being encountered in telegraphy, telephony, radio and tv program transmission, and finally also data transmission.

In the Siemens organization the Transmission Division (Wernerwerk für Weitverkehrs- und Kabeltechnik) is responsible for long-range communications. Supported by modernly equipped laboratories and designing offices active in all fields of communications engineering, current and future development problems of transmission technology are here studied. Communications lines and

Fig. 1 A large section of the personnel of the Transmission Division work in this building: members of the engineering department and the accounting and marketing department

Fig. 2 A continuous line of development runs from the cable press devised by Werner Siemens in 1847 for the seamless extrusion of lines with gutta percha – the first of its type ever known – to the machines for coaxial lines built about a hundred years later. Fed with copper strip, the special jig here seen forms tubular outer conductors over the inner conductors and their polyethylene disks. Even over many hundred miles the internal diameter must not deviate by more than a few hundred parts of a millimeter from its nominal value

Fig. 3 Versatile installation personnel at the sites of repeater stations integrate the communications bays according to carefully prepared plans. Trunking cable and jumper wires, distribution racks, combining frames, cable runways and other station installation material is here used

networks of all types and sizes are planned and constructed through close interdepartmental cooperation and handed over to customers ready for operation. In connection with these activities, the Transmission Division supplies land and marine cables, lines, loading coils and other accessories for long-line networks; all the material required in the construction of complete local networks, including the subscriber lines;

Fig. 4 Antenna cables with high power ratings and operated at frequencies up to 4 gigacycles are put through a thoroughgoing test at this measuring station maintained by our department for cable development and production. In a minimum of time the sweep measuring setup furnishes an accurate picture of the slight frequency-dependence of the cable reflection coefficient for later evaluation in production and application

Fig. 5 The required high transmission performance and operational reliability of transmission equipment call for intermediate quality control checks during the production of components and sub-assemblies and equally stringent final testing. For long production runs, automatic measuring setups considerably shorten the time taken up by such quality control tests. At the measuring setup here seen a rigid program of measurements is conducted on long runs of carrier channel modulators

audio and carrier equipment, radio relay systems, frequency-multiplex and time-multiplex equipment for cable and radio paths with telephone and radio program channels; equipment for the transmission of tv signals; remote monitoring and control equipment; power supply systems.

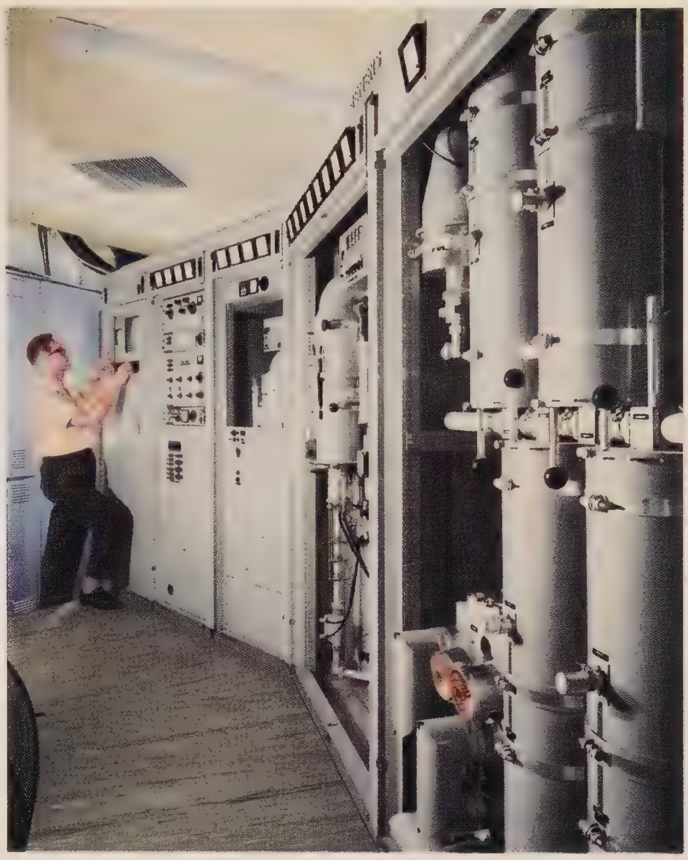
The development of high-power shortwave transmitters for telephony and telegraphy led to the development and construction of large-size transmitters for any frequency band and associated antenna systems for radio broadcasting and television.

The special components essential for such equipment and the communications measuring equipment required in the development, production and operation of long-range communications systems are also included in our line of products.

Backed by more than a 100 years of experience gathered in all parts of the world and continuously engaged in following up new ideas and techniques on a well-planned cooperative basis, the Siemens Transmission Division stands in the service of long-line communications engineering in its broadest sense.

Fig. 6 The sweep measuring setup is steadily gaining in status among the large collection of communications measuring equipment for fast, accurate measurements in development, production, installation and operation. It is today also available adapted for broadband systems and microwave frequencies.
The photograph shows several of these measuring setups being used for trimming transmitting and receiving filters, i-f amplifiers, and other items of radio link equipment

Fig. 7 Communications transmission technology normally operates with very low powers in the order of milliwatts and watts. In the development and production of transmitting systems for long-range shortwave radiocommunication, radio broadcasting and television, the control of high powers at frequencies sometimes high up in the microwave range is called for in addition to high transmission performance and operational reliability. A 20-kw transmitter for the UHF-TV band (470 to 614 mc) is here seen



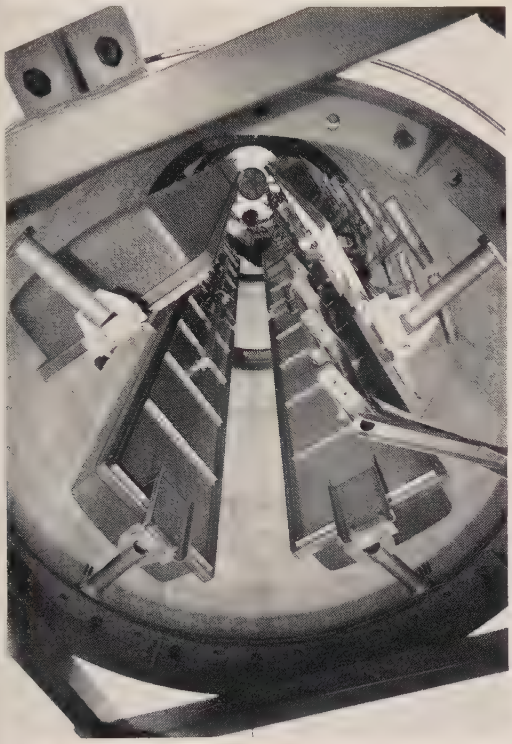


Fig. 8 One of the many examples of the close ties between transmission techniques for telephony, telegraphy, radio broadcasting and television is reflected in the antenna technique: unit arrays can be assembled to construct high-directivity antennas or omnidirectional antennas that secure optimum "illumination" of their respective distribution areas

Fig. 9 The production of cables and lines, components, transmission equipment and bays, etc., is distributed among various factories in West Germany and West Berlin. The factory here seen is in West Berlin

The Long-life Single-phase A.C. Meter W 204 for Load-rate Metering

By Friedrich Schmidt

Some years ago, the Nürnberger Zählerwerk of Siemens-Schuckertwerke developed an a.c. meter with a very high electrical, magnetic and mechanical stability, ensuring constancy of the metering characteristics over a long period. This meter can therefore be used without major overhaul for a much longer time than the present electricity meters, resulting in greater economy.

Special features making for the long-life characteristic of this meter are:

- Accuracy in metering
- Mechanical stability
- High dielectric strength
- Oil-free bearings of low friction and high resistance to wear
- Short-circuit-proof, non-ageing dual-flux brake magnet
- Terminal block with resilient box-type terminals with clamping plate

The progress in meter engineering resulting from these improvements gave rise to the development of load-rate credit meters which are designed on the same principle. Load-rate credit meters have two registers, one for registering the total energy and one for registering the energy in excess of a definite amount of energy agreed upon with the consumer.

To permit comparison, Fig. 1 shows on the right the new load-rate credit meter W 204 sL, and on the left the long-life meter W 204. As can be seen, the same casing is used for both meters. In addition, the long-life meter W 204 could be converted into a load-rate credit meter without any change in design, the standard register merely being replaced by an excess-load element (with excess energy and total energy registers). Thus, for the first time a load-rate credit meter is available with the same metering element, the same casing and the same dimensions as the basic type.

In the event of changes in the electricity tariff, the power supply companies consequently can in their own meter shops quite simply convert the meter W 204 into a load-rate credit meter and vice versa. No difficulties will be experienced when replacing the meters as the fixing dimensions are the same.

The novel design utilizes the properties and good moulding characteristics of the modern plastic materials and applies them to the components of the excess-load device. Thus, the dimensions could be adapted to suit the

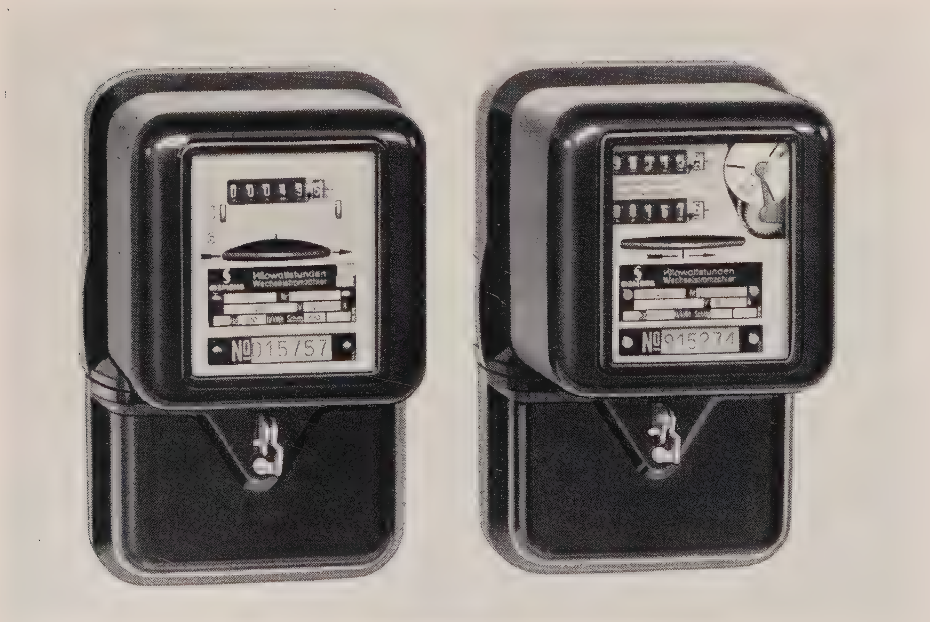


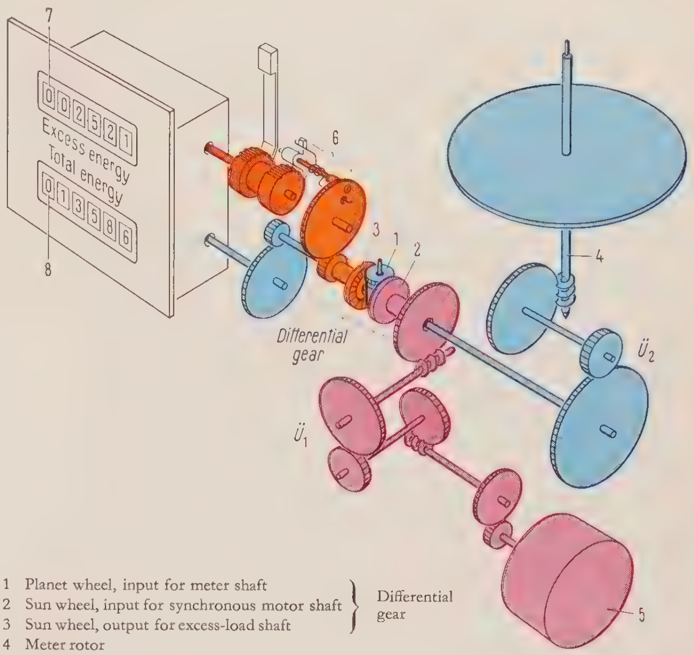
Fig. 1 Long-life meter W 204 (left) and load-rate credit meter W 204 sL (right)

limited space available, enabling the element to be designed with the same favourable features as the meter W 204.

The excess-load device

Mode of operation

The excess load is determined on the principle of the comparison of rotational speeds (Fig. 2). Two different speeds are imparted to a differential gear which forms the difference in these two input speeds. The output shaft (3) of the differential gear rotates at the rate of the difference of the two speeds and the distance travelled corresponds to the time integral of this difference. One speed is proportional to the power consumed by the load, and the other is constant and corresponds to the limit load agreed upon with the consumer. Accordingly, the input (1) of the differential gear is driven via gear trains from the meter shaft (4), the other input (2) being driven via gear trains from a miniature synchronous motor (5). The revolutions of the output (3) of the differential gear, which are proportional to the excess load, are transmitted via an overrunning clutch (6) to the excess-energy register (7). The overrunning clutch serves to prevent reversing of the cipher rolls of the register when the load is below the predetermined limit load. The total-energy register (8) is driven directly from the meter shaft via the reduction gear train $\ddot{U}_2$ and the shaft which passes through the differential gear.



1 Planet wheel, input for meter shaft
2 Sun wheel, input for synchronous motor shaft
3 Sun wheel, output for excess-load shaft
(1–3: Differential gear)
4 Meter rotor
5 Miniature synchronous motor
6 Overrunning clutch
7 Excess-energy register
8 Total-energy register
$\ddot{U}_1$ Pair of change gears for setting the load limit (subtraction gears)
$\ddot{U}_2$ Pair of change gears for adapting the registers to the rated meter load

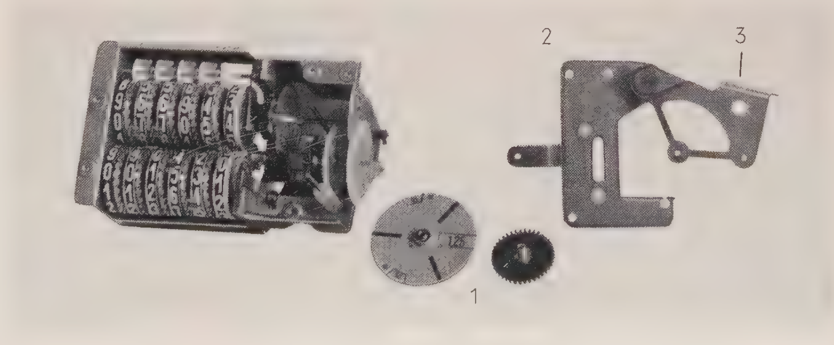
Fig. 2 Schematic representation of the load-rate credit meter

To permit setting of a definite limit load, which may also be termed subtraction load, the gear ratio between the synchronous motor and the respective input of the differential gear must be variable. This is provided for by means of the subtraction gear train $\ddot{U}_1$.

Construction

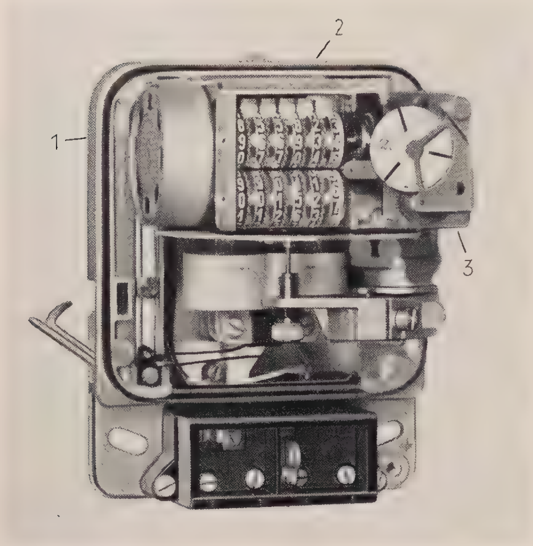
The new excess-load element (see Fig. 3) is designed along the lines of the time-proved single-rate register of the new long-life meters W 204 and D 304. It is enclosed by a sturdy torsion-resistant case of corrosion-resistant die-cast aluminium. The left-hand compartment of the case accommodates the excess-energy and total-energy registers, while the right-hand compartment houses the subtraction gears, the overrunning clutch and the shafts for the easily accessible subtraction gear wheels which can be replaced without the use of any tool.

Worms and worm wheels, all sleeves and, as far as necessary, the gear wheels of the excess-load device are of polyurethane. The components made of this thermoplastic material are distinguished, among other things, by their low water absorption and high surface finish, high ductility and resistance to wear. The low weight of these gear members and the use of stainless steel spindles of small diameters, together with the plastic bearing sleeves, make for bearings which need not be oiled and which show no signs of wear or any noticeable change in the particularly low frictional torque even after years of service. The frictional torque of the excess-load device is only about a 150th of the meter torque at 10% of the rated meter load.



1 Subtraction gear train $\ddot{U}_1$ 2 Front bearing plate 3 Laterally hinged spring clip

Fig. 3 Excess-load device (front bearing plate removed)



1 Synchronous motor 2 Excess-load device 3 Subtraction gear train $\ddot{U}_1$

Fig. 4 Load-rate credit meter W 204 sL, cover removed

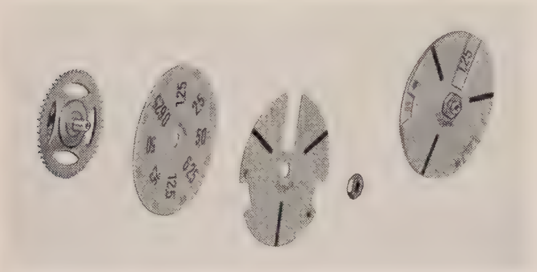
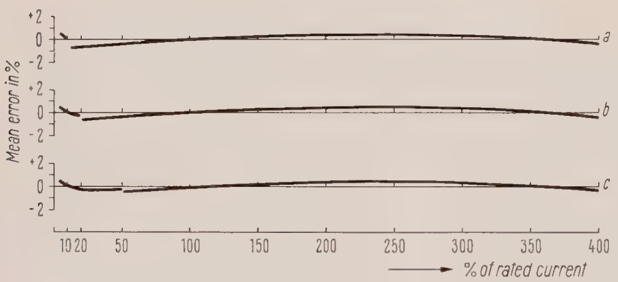


Fig. 5 Exploded view of a subtraction wheel



a Subtraction load set to 10% of rated load *b* Subtraction load set to 20% of rated load *c* Subtraction load set to 50% of rated load

Fig. 6 Mean error curves of the W 204 sL at unity power factor

The use of components of thermoplastic materials offers the big advantage that small and complex parts can be manufactured economically in large numbers and with uniform quality. The freedom in the choice of shapes has been utilized to a large degree in order to obtain a very compact design. The gears and bearing parts are the outcome of a development which was carried out years ago to obtain the long-life features. This development proves today to be an advantage to the excess-load device.

The synchronous motor is a low-speed hysteresis motor with a high reserve capacity, which has stood the test for years. Its dielectric strength corresponds to that of the other meter components. It can be seen in Fig. 4 to the left of the excess-load element. For thirty years synchronous motors have given reliable service in tariff meters and other precision apparatus.

The subtraction gear wheels $\ddot{U}_1$ can be easily replaced when changing the power limit; they are slid on and secured in place by means of a laterally hinged spring bracket (see Figs. 3 and 4). A dial marked with several figures is firmly riveted to one of these wheels and is covered by a rotating screen with three windows, which is held in a definite position by a nut. The design of this wheel can be seen from Fig. 5. The eight equally spaced index figures marked on the periphery of this dial indicate the ratio of the pair of gear wheels, the eight different figures show the possible subtractive limit loads in kilowatts. Apart from the index figure, only one limit load figure appears in the windows of the screen. This type of indication of the subtractive limit load set in the meter prevents the wrong gear wheels from being fitted if the rated load marked on the name-plate, and the index figure and the value of the subtractive limit load of the subtraction wheels correspond to the values of our subtraction load table. The gear ratio can be checked without removing the meter cover (and lead seals). The marking of different limit loads on the dial of the pair of gear wheels indicates that the same pair of gears can also be used in other meters which are built for a corresponding rated load.

The ratios of the subtraction gear wheels provided are so matched that the subtraction load can be selected between 10 and 250% of the rated meter load in fine steps of approximately 1 per cent of the maximum value.

The degree of reaction on the meter is the decisive factor for assessing the quality of the new excess-load device. As can be expected from the low friction of the excess-load device, the resulting additional error is rather small. It appears as soon as the excess-energy register starts to operate, but decreases rapidly with increasing subtraction load and increasing current load of the meter. Fig. 6 shows the mean error curve of the meter for three different subtraction loads. At a set subtraction load of 50% of the rated load the maximum additional error is only about 0.2 per cent, a value which in practice can be neglected.

Over the important working range the load-rate credit meter W 204 sL has the same metering accuracy as the long-life meter W 204 together with all the characteristics of the latter.

NEW EQUIPMENT

Expansion of EMD Dial Offices in Venezuela

By Erich Steger

The first EMD dial offices to be exported overseas were placed in service in Caracas, capital of Venezuela, at the beginning of 1955 [1]. In the interim large telephone networks operating with EMD switches have also grown up in many other overseas countries as well.

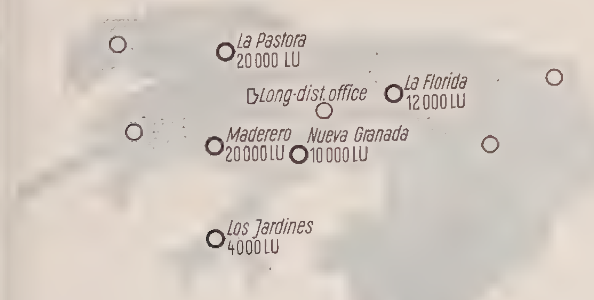
In 1958 the Venezuelan PTT awarded an order for the expansion of several dial offices in Caracas. As the first stage of development, 2,000 additional subscriber line units were placed in service at the La Florida dial office at the beginning of 1960. This office today has a total of 12,000 line units (see Fig. 1); a further 3,000 line units are at present being installed. By February 1960 the expansion of the Los Jardines dial office from 2,000 to 4,000 line units was completed. Other dial offices such as Nueva Granada were also expanded considerably during the course of the year. It is hoped in this way to meet at least the most urgent requirements for new subscriber lines.

The new racks have a height of just over 12 ft the same as those installed previously. This height is well suited to the lofty rooms in the dial office buildings and saves much space. The alarm lamps and power supply leads are installed between the top and bottom halves of the racks, each of which accommodates twelve 200-pt EMD switches (Fig. 2). Traveling ladders in the gangways between the lines of racks give maintenance personnel and troubleshooters easy access to the top switches. Exclusive use is made of 200-pt EMD switches, which are capable of testing 20 outlets in each of 10 routes, so permitting the optimum utilization of interoffice trunks.

This time the PTT specified a higher erlang value for the new offices on account of the fact that the flat rate that subscribers in Venezuela are charged encourages them to originate more calls.

The new office sections are equipped with automatic routiners [2], automatic power supply systems [3] and automatic traffic recorder-printers, with the aid of which maintenance costs are reduced and operating reliability at the same time improved.

As before, the new equipment has been installed for the most part by Venezuelan fitters, who will later be responsible for maintenance and routining.



EMD offices
Two-motion switch offices
LU Subscriber line units

Fig. 1 Location of dial offices in city area of Caracas

Fig. 2 Inside an EMD office in Caracas

The EMD dial offices in Caracas have given excellent performance under extremely difficult conditions and in the face of heavy traffic. It is this fact in particular to which the awarding of the new orders must be ascribed.

Bibliography

[1] Steger, E.: Erstes EMD-Wähleramt in Übersee. Siemens-Zeitschrift **29** (1955) pp. 251 and 252

[2] Purzer, J. and Sedlmayr, O.: Test Equipment for EMD Dial Offices. Siemens Review XXVI (1959) pp. 268 to 270

[3] Fried, Th. and Braun, K.: Power Supply System of Mannheim's Communications Building. Siemens Review XXVIII (1961) pp. 110 to 113

Telephone Transmitter with Transistor Amplifier

By Günter Fordan

The "transistor transmitter" consists of a quality magnetic microphone system structurally combined with a two-stage transistor amplifier in a transmitter inset of normal size[1]. As the transmitter with transistor amplifier has the same input current as a conventional carbon transmitter, it can readily be used as a replacement for the latter. Its transmitting characteristics are outstanding.

1 Hörner, O. and Langsdorff, W.: Repeaters in Local Telephone Networks and PABXs. Siemens Review XXVI (1959) pp. 218 to 225

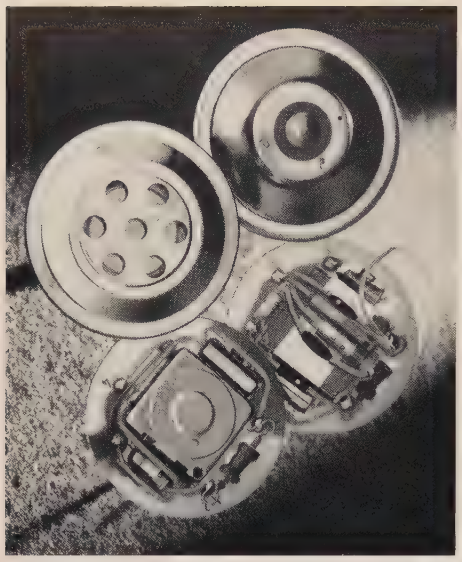


Fig. 1 Front and rear of transmitter inset with transistor amplifier; below: open view of inset

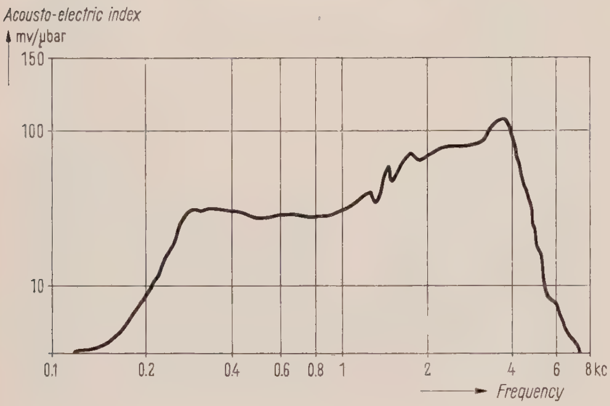


Fig. 2 Acousto-electric index as a function of frequency and assuming an acoustic pressure of 10 microbars

Constructional design and matching

The magnetic transmitter and transistor amplifier form a compact self-contained unit (Fig. 1). As mismatch is negligible, no transformer is required for coupling the two amplifier stages. The output impedance of the power stage is about 300 ohms, which satisfactorily matches the impedance of the hybrid transformer in the telephone.

The transmitter with transistor amplifier is ready for service the moment it is cut in when the telephone user removes his handset. It operates with a loop current of 28 to 64 ma, which represents a transmitter current of about 20 to 50 ma in the telephone circuit. Negative battery potential must be applied to the inset during operation. A special model is designed for local battery systems with 6 v (current input 15 ma). The d-c resistance is about 150 ohms. A working-point stabilizer and tantalytic capacitors insure proper operation of the amplifier at temperatures ranging from −20 to +60 °C.

Transmitting characteristics

The magnetic transmitter secures particularly good speech intelligibility by favoring the treble frequencies. As the nonlinear distortion factor is only about 3% for an acoustic pressure of 10 microbars, no modulation of the signal level with the noise level occurs during conversation in loud rooms. As the result of degeneration, the frequency response of the amplifier is practically flat between 300 and 4,000 cps. Fig. 2 shows the acousto-electric index of the overall system (transmitter and amplifier). For amplifier noise voltages up to 0.5 mv the signal-to-noise ratio referred to 0 db is better than 1,000:1. A special transmitter inset with a very low acousto-electric index is available for loud rooms.

Like carbon transmitters, the new magnetic transmitters are classified according to their sending reference equivalent (volume classes I and II). The sending reference equivalent is fixed for each inset. The transmitter and its quality components insure a sending reference equivalent that always remains the same regardless of how long the inset is kept on the shelf. The effect of variations in feed currents and acoustic pressure is negligibly small.

Applications

The greater engineering effort and consequently higher price as compared with the conventional carbon transmitter is well justified in view of the suitability of the new transmitter with transistor amplifier for special applications. Among other things it may be used to advantage for telephoning in loud rooms, for the reproduction of telephone conversations over a loudspeaker, or as a built-in unit in entrance converser stations, where acoustic pressure will be low on account of the relatively great distance between the transmitter and the person speaking. With all these applications outstanding speech intelligibility is achieved.

Managing Editor: H. Hosang, Erlangen · Editors: G. Kaerger and K. Holzwarth, Erlangen
Edited and published by: Siemens & Halske AG · Siemens-Schuckertwerke AG · Berlin · München · Erlangen
Printed by: Buchdruckerei AG Passavia, Passau, Steinweg 8

Summaries of Contributions to the Siemens Review, Vol. XXVIII, No. 4/1961

For cutting out and pasting on index cards

SIEMENS U.D.C. 681.177.2:66.022:621.929

Walther Kirchner

Punched-card Control for Mixing Plants

3½ pages, 5 figures

Siemens Review XXVIII (1961) pp. 103 to 106

A description is given of the part played by punched-card controls in obtaining a high-grade end product at optimum processing speed in mixing plants. The article shows how punched-card control can be applied to various mixing processes. A decisive factor is the type of construction of the balance scales and their mode of operation within the framework of the mixing programme.

SIEMENS U.D.C. 681.177.2:66.022:621.929

Adolf Reese

Punched-card Equipment for the Control of Mixing Plants

4 pages, 6 figures

Siemens Review XXVIII (1961) pp. 106 to 110

In mixing plants, the selection and quantities of the various basic materials can be controlled by a punched-card system. A description is given of the equipment required for the conventional weighing method.
Also dealt with in the article are punched-card reading stations, relay combinations for the individual operations and their subdivision on the tetradic principle.

SIEMENS U.D.C. 621.39:621.311.4

Theodor Fried and Karl Braun

Power Supply System of Mannheim's Communications Building

3 pages, 5 figures

Siemens Review XXVIII (1961) pp. 110 to 113

A new full-automatic power supply system has been installed for powering the telephone, telegraph and radio-communication equipment at the Mannheim sectional office, which has been considerably expanded in recent years.
The operating principle of the power supply system and the functions of the various items of equipment during feeding from the commercial a-c mains and battery operation is described.

SIEMENS U.D.C.621.316.718:621.318.435.3:681.624.4

Werner Leonhard and Walter Preis

Transductor-fed Variable-speed Drives for Rotary Printing Presses

5½ pages, 8 figures, bibliography

Siemens Review XXVIII (1961) pp. 113 to 118

Many new rotary printing presses are being equipped with transductor-fed d.c. drives. To enable the printing press to meet the varying requirements of the printing programme, sectional drives are employed so that where necessary each printing unit has its own drive motor with the associated transductor. When the motors are mechanically coupled via the press, high-speed control is required to distribute the load. A description is given of a control system in which each of the motors is provided with its own current controller, the current reference values being injected into a superordinated speed controller. The controllers are constructed entirely of static components and the speed range is about 1 : 100.

SIEMENS U.D.C. 621.394.324:621.396

Hans Heinrich Voss

Radiotelegraphy

6 pages, 10 figures, 1 table, bibliography

Siemens Review XXVIII (1961) pp. 119 to 124

Radiotelegraphy systems operate in practically all wavebands except the standard broadcast band. The different characteristics of the various wavebands determine their range, suitability for certain services, and the grade of difficulties to be overcome. A review is given of a number of different methods of telegraph transmission and message protection used to meet various requirements.

SIEMENS U.D.C. 621.316.718:622.66

Hans-Joachim Henke and Ingemar Neuffer

Operating Experience gained with Siemens Transistor Control for Mercury-arc Rectifier-fed Winders

3 pages, 6 figures, bibliography

Siemens Review XXVIII (1961) pp. 125 to 127

The control principle selected is explained by means of a general circuit diagram and the performance of the winder illustrated by oscillograms.
The two large time constants of the drive are co-ordinated with the current control circuit and the speed control circuit which is superimposed on this. Starting and retardation of the winder is controlled by a special unit. The construction of the control equipment is simplified by a slide-in tray arrangement on which the transistor components are grouped according to their function. This also reduces the time required for commissioning.

SIEMENS U.D.C. 621.317.785.025

Friedrich Schmidt

The Long-life Single-phase A.C. Meter W 204 for Load-rate Metering

3 pages, 6 figures

Siemens Review XXVIII (1961) pp. 132 to 134

The long-life single-phase a.c. watthour meter W 204 can be easily converted in any meter workshop into a load-rate meter. For this, the single-rate register is simply replaced by a load-rate register. The new load-rate register operates on the principle of speed comparison. The gears and the bearings are made of high-grade plastics. The friction produced in the oil-free hard wearing bearings is limited and the reaction of the new register on the metering element negligible. The excellent characteristics of the W 204 are retained in full.

SIEMENS U.D.C. 621.395.72(87)

Erich Steger

Expansion of EMD Dial Offices in Venezuela

1 page, 2 figures, bibliography

Siemens Review XXVIII (1961) p. 135

Placed in service in 1955 in Caracas, Venezuela, the first EMD dial offices installed overseas are now undergoing considerable expansion. The existing equipment and the special features of the equipment that is being added are reviewed.

SIEMENS U.D.C. 621.395.613.32:621.375.4

Günter Fordan

Telephone Transmitter with Transistor Amplifier

1 page, 2 figures

Siemens Review XXVIII (1961) pp. 135 and 136

The new transmitter inset with transistor amplifier furnishes the highest transmission performance and can readily be used in place of a carbon transmitter. Description of constructional design, matching and transmission characteristics. Applications: telephones in general, noisy rooms, loudspeaker systems, electric doorman systems.

SIEMENS